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Physical activity in the management of type 2 diabetes mellitus

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Research conducted within the University of Wales Institute, Cardiff in collaboration with Cardiff University and the Western Health and Social Care Trust
“Our greatest glory is not in never falling, but in rising every time we fall”

Confucius (551-479 BC)
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Abstract

The incidence of type 2 diabetes mellitus (T2DM) is rising throughout the world. Explicit evidence has demonstrated sedentary behaviour is a powerful but modifiable risk factor affecting glycaemic control and the incidence of diabetes complications. Despite this, current population estimates indicate the importance of physical activity is not effectively translated to the T2DM population. The aim of this thesis was therefore to investigate barriers and facilitators to physical activity behaviour among individuals with T2DM. An extensive literature review investigating evidence linking physical activity to the management of T2DM was performed, then followed on by three studies which 1) investigated the effects of a 12-week supported exercise programme among newly diagnosed patients, 2) explored factors that may be associated with sedentary or physical activity behaviour, and 3) compared and contrasted the perception and use of physical activity among patients who participated in an exercise programme and patients who received standard care. The findings of this thesis demonstrated that a supported exercise programme can help newly diagnosed T2DM patients achieve moderate-high intensity physical activity 3-5 days·week\(^{-1}\), improving glycaemic control through enhanced β-cell function associated with decreased insulin resistance and improved lipid profile. Exploratory investigation suggested self-efficacy to exercise, internal locus of control and physical activity advice may be important antecedents for physical activity behaviour. Furthermore, it also appeared to suggest that peer support and more comprehensive physical activity information and reinforcement, are key to satisfying psychological needs - autonomy, competence and relatedness - and internalising motivation for physical activity and exercise behaviour. Given the projected incidence of T2DM and prevalence of sedentary behaviour among this population, the findings from this thesis highlight the important role of physical activity and also the need for further research investigating supported exercise programmes and the development of more comprehensive physical activity guidelines for individuals with T2DM.
Abbreviations

%, percentage
AAC, area above the curve
ACSM, American College of Sports Medicine
AD, anti-diabetic drugs
ADA, American Diabetes Association
ANOVA, analysis of variance
ART, combined aerobic and resistance training
AT, aerobic training
AUC, area under the curve
BMI, body mass index
C, control group
cm, centimetre
CVD, cardiovascular disease
CWT, circuit weight training
D, weekly duration
DI, disposition index
DSE, diabetes support and education
DSMEP, diabetes self-management education programme
E, exercise group
ECG, electrocardiogram
Ex., exercises
FPG, fasting plasma glucose
FSIVGTT, frequently sampled intravenous glucose tolerance test
HbA1c, glycosylated haemoglobin
HCCQ, Health Care Climate Questionnaire
HDL, high-density lipoprotein
HI, high intensity
HOMA, homeostasis model assessment
HR$_{\text{max}}$, maximal heart rate
HRR, heart rate reserve
ID, intensive diaetary support
IFG, impaired fasting glucose
IGT, impaired glucose tolerance
ILI, intensive lifestyle weightloss intervention
IR, insulin resistance
kcal, kilocalorie
kg, kilogram
l, litre
LDL, low-density lipoprotein
LoC, Locus of Control
Look AHEAD, Action for Health in Diabetes
m, metre
M₀, fasting β-cell function
M₁, postprandial β-cell function
MET, metabolic equivalent
MI, moderate intensity
min, minute
ml, millilitre
mmHg, millimetre of mercury
mmol, millimole
MTT, meal tolerance test
n, number
NEFA, nonesterified fatty acid
NGT, normal glucose tolerance
NICE, National Institute for Health and Clinical Excellence (UK)
NIDDM, Non-insulin dependent diabetes
NS, not significant
OGTT, oral glucose tolerance test
P, probability (level of significance)
PA, physical activity advice
pmol, picomole
PNSE, Psychological Needs Satisfaction in Exercise
PRT, progressive resistance training
r.a., randomised to
RM, repetition maximum
RT, resistance training
s, session
SCP, standard care programme
SDT, Self-determination Theory
SE, self-efficacy
SEP, supported exercise programme
$S_g$, glucose effectiveness
$S_t$, insulin sensitivity
SoC, stages of change
SPSS, Statistical Package for Social Science
TC, total cholesterol
TG, triglycerides
TM, training modality
TSRQ, Treatment Self-Regulation Questionnaire
TTM, Transtheoretical Model
UK, United Kingdom
UKPDS, United Kingdom Prospective Diabetes Study
US, United States
VO$_{2\text{max}}$, maximal oxygen consumption
VO$_{2\text{peak}}$, peak oxygen uptake
Vs., versus
W, duration of programme in weeks
WL, weight loss
Glossary of terms

**Acute insulin response to glucose (AIR<sub>g</sub>):** The body’s insulin response to the intravenous glucose.

**Aerobic exercise:** This consists of rhythmic, repeated, and continuous movements of the same large muscle groups for at least 10 minutes at a time. Examples include walking, bicycling, jogging, continuous swimming, water aerobics, and many sports. When performed at sufficient intensity and frequency, this type of exercise increases cardiorespiratory fitness.

**Age:** The participants’ ages at baseline.

**Area under the curve (AUC):** AUC can be calculated for any time period of a profile. For example in the case of an insulin profile; AUC<sub>0-30min</sub> a measure of “first phase” insulin release, AUC<sub>30-240min</sub> a measure of “second phase” insulin release, and AUC<sub>0-240min</sub> a measure of total postprandial insulin release.

**Atherogenic:** Tending to cause atherosclerosis

**Atherosclerosis:** Is a disease affecting the arterial blood vessel. It is caused by the formation of multiple plaques within the arteries.

**Blood glucose:** The main sugar that the body makes, mostly from carbohydrates, as well as from the other two elements of food – proteins and fats. Glucose is the major source of energy for living cells and is carried to each cell through the bloodstream.

**Body Mass Index (BMI):** BMI describes a particular relationship between an individual’s body mass and their height, and this relationship is defined by the formula: BMI = body mass (in kilograms) / height<sup>2</sup> (in metres). In lay terms, BMI denotes the leanness (low BMI values) or fatness (high BMI values) of an individual (true of the general population, however not necessarily true for an athletically trained individual). A BMI of 20–25 is considered normal, >25 is overweight and >30 is obese (>40 is often termed clinically or morbidly obese).

**Cardiorespiratory fitness (also known as cardiorespiratory endurance or aerobic fitness):** The ability of the circulatory and respiratory systems to supply oxygen during sustained physical activity. The gold standard for measurement of cardiorespiratory fitness is a test of maximal oxygen uptake (VO<sub>2max</sub>), typically performed using indirect calorimetry on a treadmill or bicycle ergometer. Cardiorespiratory fitness can be estimated accurately using graded maximal exercise testing on standard treadmill or bicycle ergometer protocols without indirect calorimetry.

**Cardiovascular disease (CVD):** Disease of the heart or vessels of the circulation.

**Central tendency bias:** A tendency by respondents to rate or score around the midpoint of a scale and not use the extremes, sometimes referred to as a central tendency error.
Coronary heart disease: Also known as ischaemic heart disease.

C-peptide: Serves as a link between the A- and B-chains of insulin and facilitates the efficient assembly, folding and processing of insulin in the endoplasmic reticulum. Equimolar amounts of C-peptide and insulin are stored and secreted by the pancreatic β-cells. As C-peptide does not undergo hepatic metabolism like insulin, it is used to measure pre-hepatic insulin secretion rates.

Diabetes mellitus: A disease involving a disturbance of metabolism, the underlying cause of which being the defective production or action of the hormone insulin. There are several manifestations of the disease, the most common being type 1 and type 2.

Dietician: An expert in nutrition who helps people with special health needs to plan the kind and amount of foods to eat.

Disposition index (DI): A measure of the overall ability of the islet cells to secrete insulin normalised to the degree of insulin resistance.

Epidemiology: The study of the distribution and determinants of health-related states or events in specified populations.

Exercise: A subset of physical activity: planned, structured, and repetitive bodily movement performed to improve or maintain one or more components of physical fitness or the improvement of some aspect of health.

Fasting β-cell responsiveness (M₀): Ability of fasting glucose to stimulate insulin secretion.

Flexibility: This term refers to the range of motion available at joints.

Flexibility exercise: This is exercise (typically stretching) aimed at increasing or maintaining range of motion at joints.

Frequently sampled intravenous glucose tolerance test (FSIVGTT): A direct challenge of glucose on the β-cell which is not affected by gut factors, such as gastric emptying or gut hormones. The challenge consists of a bolus of glucose administered over a 2 minute period, followed by a bolus of insulin administered at 20 minutes.

Glucose effectiveness (S₉): Ability of glucose to promote its own disposal – amount of glucose pool is cleared per minute at basal insulin.

Glycosylated haemoglobin (HbA₁c): A blood test used to measure glycosylated haemoglobin levels which indicate average glycaemic control over the preceding 3 months.

Healthcare professional: A person who by education, training, certification, or licensure is qualified to and is engaged in providing health care.

Healthcare provider: An individual who provides health services to healthcare consumers (patients).
**Health status**: A set of measurements that reflect the health of populations. The measurements may include physical function, emotional wellbeing, and activities of daily living.

**High-density lipoprotein (HDL) and low-density lipoprotein (LDL)**: HDL and LDL make up cholesterol. The levels and ratios of HDL and LDL are predictors of cardiovascular disease.

**Homeostasis model assessment (HOMA)**: Estimates steady state β-cell function (%B) and insulin sensitivity (%S), as percentages of a normal reference population.

**Hyperglycaemia**: Elevation of blood glucose. Over an extended duration it is associated with the development of diabetes complications.

**Hyperinsulinemic euglycemic clamp**: A laboratory test procedure for investigating and quantifying insulin resistance. The hyperinsulinemic euglycemic clamp measures the amount of glucose necessary to compensate for an increased insulin level without causing hypoglycaemia.

**Hypoglycaemia**: A low level of blood glucose. Associated with an elevated level of insulin in insulin-dependent diabetics, it can lead to performance changes, but is not always symptomatic.

**I score**: Individual response score.

**Incidence**: The number of new cases or deaths in a given period in a specified population.

**Insulin**: A hormone that helps the body use glucose for energy. The β-cells in the pancreas (in areas called the Islets of Langerhans) make the insulin. When the body cannot make enough insulin on its own, a person with diabetes can inject insulin made from other sources.

**Insulin sensitivity (S)**: Ability of insulin to enhance glucose disposal – how much 1 unit of insulin changes the glucose disposal.

**Intensity of aerobic exercise**: This will be described as “moderate” when it is at 40–60% of VO\(_{2}\)\(_{\text{max}}\) (50–70% of maximum heart rate) and “vigorous” when it is at \(\geq 60\%\) of VO\(_{2}\)\(_{\text{max}}\) (\(\geq 70\%\) of maximum heart rate).

**Intensity of resistance exercise**: This will be described as “high” if the resistance is \(\geq 75\%\) of the maximum that can be lifted a single time (\(\geq 75\%\) of 1-RM [repetition maximum]) and “moderate” if resistance is 50–74% of 1-RM.

**Intervention**: A specific prevention measure or activity designed to meet a programme objective.

**Likert scaling**: Likert scaling is a bipolar scaling method, measuring either positive or negative response to a statement. Likert scales may be subject to distortion, for example central tendency bias and social desirability bias.
Lipid: A term for some forms of fat.

Macrovascular complications: Diabetes complications from large blood vessel disease. Includes coronary heart disease, stroke, peripheral vascular disease, hypertension.

Meal tolerance test (MTT): A complex carbohydrate challenge, which examines the β-cell response to a mixed meal challenge. It is more physiological than either the oral glucose tolerance test (OGTT) or frequently sampled intravenous glucose tolerance test (FSIVGTT). The MTT consists of a mixed meal of 500 kcal (20% protein, 22% fat and 58% carbohydrate), containing approximately 75g of carbohydrate.

Metabolic equivalent (MET): A MET is a unit of intensity equal to energy expenditure at rest. Physical activity at 3 METs uses three times as much energy as stationary sitting. MET-hours are units of exercise volume in which intensity in METs is multiplied by duration of the activity in hours.

Microvascular complications: Diabetes complications from small blood vessel disease; includes retinopathy (damage to eye), nephropathy (damage to kidneys), neuropathy (damage to nerves).

Morbidity: Disease state of an individual, or the incidence of illness in a population.

Mortality: The incidence of death (number of deaths) in a population.

Muscular fitness: This refers to strength (the amount of force a muscle can exert) and muscular endurance (the ability of the muscle to continue to perform without fatigue).

Nephropathy: Disease of the kidneys caused by damage to the small blood vessels or to the units in the kidneys that clean the blood. People who have had diabetes for a long time may have kidney damage.

Neuropathy: Disease of the nervous system. Many people who have had diabetes for a number of years are likely to have nerve damage. The most common form is peripheral neuropathy, which mainly affects the feet and legs. Nerve damage in the feet and legs can lead to diabetic gangrene.

Obesity: When people have 20 percent (or more) extra body fat for their age, height, sex and bone structure, fat works against the action of insulin. BMI > 30 (see BMI).

Objective: The end result a programme seeks to achieve.

Overweight: Body weight that is above the recommended level, due to increased body fat. 25 < BMI > 30 (see BMI).

Physical activity: Bodily movement produced by the contraction of skeletal muscle that requires energy expenditure in excess of resting energy expenditure.
**Physical fitness**: This includes cardiorespiratory fitness, muscular fitness, and flexibility.

**Postprandial β-cell responsiveness (M₁)**: Ability of postprandial glucose to step up insulin secretion.

**Prevalence**: The number of instances of a given disease or other condition in a population at a designated time. Prevalence includes both new (incidence) and existing instances of a disease.

**Psychosocial**: Relating to both the psychological and the social aspects of something.

**Quality of life**: An individual’s perception of their position in life in the context of the culture in which they live, and in relation to their goals, expectations and standards. The term incorporates concepts of physical and psychological wellbeing, levels of independence and autonomy, social relationships and support, and spirituality.

**Resistance exercise**: Activities that use muscular strength to move a weight or work against a resistive load. Examples include weight lifting and exercises using weight machines. When performed with regularity and moderate to high intensity, resistance exercise increases muscular fitness.

**Retinopathy**: A disease of the small blood vessels in the retina of the eye.

**Risk factor**: An aspect of personal behaviour or lifestyle, an environmental exposure, or an inborn or intended characteristic that is associated with an increased risk of a person developing a disease.

**Self-efficacy**: A self-efficacy belief is a self-belief that one can perform the required behaviour that produces a specific (and desired) outcome.

**Self-management**: Self-management is now an accepted and popular term to describe both healthful behaviours and behavioural interventions, particularly for the management of chronic diseases. In self-management, the patient is an active participant in treatment.

**Social desirability bias**: A tendency for respondents to report information which is systematically biased towards respondents perceptions of what is “correct” or socially acceptable.

**Stage progression**: Stage progression describes changes in ‘exercise stages of change’ between baseline and follow-up, as assessed by the exercise stages of change scale (Marcus et al., 1992). Note that stage progression may be positive to indicate advancement from a previous stage, or negative to indicate regression from a previous stage.

**Stages of change**: The central organising construct of the Transtheoretical Model of behaviour change. The stages of change construct is important because it represents a temporal dimension and implies phenomena occurring over time.
**Standard care:** A generic term to describe a broad range of routine medical services, from prevention through to treatment and recovery.

**Tailoring:** The tailoring of an intervention or programme to specific needs of a patient, after learning the baseline characteristics of that patient. Tailoring can be amended post-baseline in response to changes.

**Type 1 diabetes:** Otherwise known as insulin-dependent diabetes mellitus (IDDM), type 1 diabetes is found most often in childhood, with secondary peaks in early and late adulthood. It is characterised by rapid onset of clinical symptoms and requires prompt medical treatment and regular use of insulin for survival. It is also termed juvenile-onset diabetes.

**Type 2 diabetes:** Otherwise known as non-insulin-dependent diabetes mellitus (NIDDM), type 2 diabetes is found primarily in adults and which accounts for most cases of diabetes. It is characterised by a gradual onset of symptoms. It is also termed mature-onset or adult diabetes.

**V score:** Variable response score.
Declaration

This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

Signed ........................................................................

Date ..........................................................................

This thesis is the result of my own investigations, except where otherwise stated. Where correction services have been used, the extent and nature of the correction is clearly marked in a footnote(s).

Other sources are acknowledged by footnotes giving explicit references. A bibliography is appended.

Signed ........................................................................

Date ..........................................................................

I hereby give consent for my thesis, if accepted, to be available for photocopying and for inter-library loan, and for the title and summary to be made available to outside organisations.

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Date ...........................................................................
Statement of collaboration

This work has been conducted within the Cardiff School of Sport, University of Wales Institute, Cardiff in collaboration with Professor David Owens, Diabetes Research Unit, Cardiff University, and Dr John Lindsay, Western Health and Social Care Trust, Altnagelvin Hospital.

Signed ...................................................................

Date ..............................................................................
Chapter 1

Introduction and thesis outline
1.1 Burden of type 2 diabetes mellitus

The prevalence of type 2 diabetes mellitus (T2DM) is rising rapidly throughout most regions of the developed and developing world (International Diabetes Federation, 2009). The emergence of the diabetes pandemic is attributable to established causes, principally the increasing number of older people and growing levels of obesity and physical inactivity (van Dieren et al., 2010). In 1995, the worldwide prevalence of T2DM was estimated to be 135 million people increasing to 171 million people in 2000 (Wild et al., 2004). The worldwide prevalence of T2DM is projected to rise from the current estimate of 366 million affected adults to some 552 million by 2030 (Diabetes in the UK 2011/2012: Key statistics on diabetes). The number of patients with T2DM is likely to be even higher than current estimates because a substantial proportion of patients with T2DM go undetected (International Diabetes Federation, 2009). Global health expenditure to treat and prevent diabetes and its complications was approximately 232 billion US dollars in 2007, a figure that will exceed 302 billion by 2025 (International Diabetes Federation, 2009).

Diabetes is the fifth most common cause of death in the world and on average life expectancy is reduced, by up to 10 years in people with T2DM (Roglic et al., 2005). In the UK, there are approximately 2.9 million people with T2DM which equates to a UK prevalence rate of 4.45% (Diabetes in the UK 2011/2012: Key statistics on diabetes) and it is estimated that there are up to 850,000 more people in the UK who have diabetes but have not been diagnosed (Holt et al., 2008). In 2008, around 400 people were diagnosed with T2DM every day and by 2025, due to an increasingly aged population and rapidly rising numbers of overweight and obese people it is estimated there will be more that 5 million people with diabetes in the UK (Diabetes in the UK 2011/2012: Key statistics on diabetes).

While good diabetes management has been shown to reduce the risk of complications (Stratton et al., 2000) it is when diabetes is not well managed, associated serious complications including heart disease, stroke, blindness, kidney disease, nerve damage and amputations leading to disability and premature mortality arise. By the time individuals are diagnosed with T2DM, around 50% of the people already show signs of complications (Stratton et al., 2000). Such complications may begin five to six years before diagnosis and the actual onset of diabetes may be up to 7 years before
clinical diagnosis (Harris et al., 1992). Based on 2007/2008 budget for the NHS of approximately £90.7 billion, it was estimated that 10 per cent of the NHS budget is spent on diabetes care, around £9 billion a year which equates to £173 million a week, £25 million a day, £1 million an hour (Diabetes in the UK 2010: Key statistics on diabetes).

1.2 Aetiology and pathophysiology of type 2 diabetes mellitus

The diagnosis of T2DM usually occurs after the age of 40 years (International Diabetes Federation, 2009) but can remain asymptomatic for many years before clinical diagnosis (Harris et al., 1992). The aetiology of T2DM has been widely researched but is not fully understood, with both environmental and genetic components believed to contribute to the condition. There are several risk factors related to the development of the condition, including: obesity, diet and physical inactivity, increasing age, family history of diabetes, sub-optimal intrauterine environment, and ethnicity (International Diabetes Federation, 2009).

The pathogenesis of T2DM is complex, involving β-cell dysfunction in the presence of insulin resistance at the level of the muscle, fat and liver (DeFronzo, 1988). T2DM is characterized by recurrent or persistent hyperglycaemia in the context of insulin resistance and relative insulin deficiency (International Diabetes Federation, 2009). Failure to appropriately manage hyperglycaemia among individuals with T2DM can lead to the development of diabetes complications - both acute and chronic adverse effects. The mechanism by which diabetes leads to complications is complex and not fully understood, but involves the direct effects of gluco- and lipotoxicity (DeFronzo, 2004) along with the impact of inflammation, oxidative stress, and endothelial dysfunction (Van den Oever et al., 2010). The major chronic complications of diabetes include: cerebrovascular disease, cardiovascular disease, peripheral vascular disease, nephropathy, neuropathy, retinopathy, ulceration and amputation (International Diabetes Federation, 2009).

1.3 Management of type 2 diabetes mellitus

The American Diabetes Association (ADA) recommends diabetic patients should strive to achieve a glycaemic target or ‘good glycaemic control’ of HbA1c ≤7.0% (ADA, Standards of Medical Care in Diabetes - 2010). However, a key challenge in
achieving good glycaemic control is an individual’s motivation to perform self-management behaviours such as monitoring diet, performing physical activity, taking medication and testing blood glucose levels (Collins et al., 2009).

In the UK the National Institute for Health and Clinical Excellence (NICE) advocated a Quality Standards Programme (2011) for the management of diabetes outlining what high-quality care should involve so that the best possible care be offered to individuals with diabetes. The quality care standard on diabetes is made up of 13 statements, the first two statements being:

1. People with diabetes and/or their carers receive a structured educational programme that fulfils the nationally agreed criteria from the time of diagnosis, with annual review and access to ongoing education

2. People with diabetes receive personalised advice on nutrition and physical activity from an appropriately trained healthcare professional or as part of a structured educational programme

NICE guidelines support a patient-centred approach acknowledging the management of diabetes involves a considerable element of self-management, and advice should, therefore, be aligned with the perceived needs and preferences of individuals with diabetes. The aim of diabetes patient education is therefore to improve individual’s knowledge, skills and confidence, enabling them to take increasing control of their own condition, make informed decisions about their care and treatment, and in partnership with their healthcare professionals integrate effective self-management into their daily lives. The Commissioning Guide on Implementing NICE Guidance (2009) suggests the potential benefits of an effective education programme include:

- Improving knowledge, health beliefs, and lifestyle changes
- Improving patient outcomes, e.g. weight, HbA1c, lipid levels, smoking, and psychosocial changes such as quality of life and levels of depression
- Improving levels of physical activity
- Reducing the need for, and potentially better targeting of, medication and other items such as blood testing strips

There are several different education programmes available across the UK for both Type 1 and T2DM, reflecting the different ways the Primary Care Trusts have gone
about establishing courses. For T2DM the most commonly referred to programmes are Diabetes Education and Self-management for Ongoing and Newly Diagnosed (DESMOND) and X-PERT. The 2009 NICE Guidance document suggests that well-designed and well-implemented programmes are likely to be cost-effective for people with diabetes and the National Service Framework (NSF) for Diabetes (2010) recommends that all Primary Care Trusts must commit to offering structured education programmes to every person with T2DM from the point of diagnosis and as an ongoing part of their therapy in the long-term. However, the success of structured education programmes such as DESMOND and X-PERT is not clear. There is evidence that not all people with T2DM are able to access structured education programmes with the Commissioning Guide on Implementing NICE Guidance (2009) suggesting as few as 10% T2DM patients attend a structured education programme at the point of diagnosis or thereafter. Furthermore, for those individuals who do attend a structured education programme, the ability of DESMOND and X-PERT to fulfil the second NICE standard pertaining to the receipt of personalised physical activity advice from an appropriately trained healthcare professional is brought into question as each of the programmes offer limited support, information and individualised consultation devoted specifically towards adopting and maintaining physical activity behaviour.

The problem of low rates of adoption of structured education programmes and the limited support they provide towards increasing physical activity behaviour is further exacerbated by Kavookjian et al. (2007) who suggests that of all the self-management behaviours individuals with T2DM find physical activity the most difficult to initiate and maintain. Despite the evolution of guidelines and recommendations (Colberg et al., 2010) reflecting the mounting evidence supporting physical activity as a vital aspect of T2DM care, recent estimates suggest only 30% of individuals with the condition achieve the recommended levels of physical activity (Plotnikoff et al., 2011a). Explicit evidence has demonstrated sedentary behaviour is a powerful but modifiable risk factor affecting both glycaemic control and the incidence of diabetes complications (Boule et al., 2001; 2003; Sigal et al., 2004; Kelley and Kelley, 2007; Colberg et al., 2010). However population estimates of physical activity behaviour among people with T2DM clearly indicates the evidence promoting this behaviour is not being effectively translated to those with T2DM. How to effectively promote
regular physical activity behaviour among people with T2DM is perhaps the most significant challenge facing researchers and healthcare providers today.

1.4 Rationale and aims
Traditionally, healthcare professionals have dictated diabetes care, an approach which does not adequately address the needs of individuals or populations with a long-standing, chronic condition such as T2DM (Norris et al., 2002). In more recent times it is suggested that effective diabetes care requires patients and healthcare professionals to collaborate in what is recognised as ‘empowerment’ paradigm or approach to care (Lorig and Holman, 2003; Anderson and Funnell, 2005). From a physical activity perspective, the empowerment approach may prove invaluable to the ongoing development of T2DM care strategies in the UK. However, although this patient-centred approach to care is advocated by NICE it is not clear whether the current standards, guidelines and structured education programmes truly attribute to the patient an active role in the management of their condition or simply continue to dictate recommendations as previous acute-care strategies have done.

It is crucial that research investigating ways of promoting physical activity behaviour among individuals with T2DM must be patient-centred. Therefore, research should embrace the empowerment approach attributing the patient an ‘active participant’ role, and seek to further understanding of the factors affecting an individual’s initiation and maintenance of physical activity self-management behaviour from a patient-oriented perspective. In order to accomplish this the present thesis sought to investigate the impact of individualised supported physical activity, explore patients’ perception of physical activity, and explore how factors may affect the use of physical activity self-management behaviour among individuals with T2DM.

Specifically the objectives of this thesis were as follows:

1. To conduct an extensive literature review in order to investigate evidence linking physical activity to the management of T2DM (Chapter 2).
2. To investigate the effects of a 12-week unsupported exercise programme (akin to standard care) and a 12-week supported exercise programme among newly diagnosed T2DM patients, with 1-year follow-up (Chapter 3).
3. To explore factors that may be associated with sedentary or physically active behaviour within a population of T2DM patients (Chapter 4).

4. To explore the perception and use of physical activity in diabetes self-management among T2DM patients who participated in an exercise programme and patients who received standard care following diagnosis (Chapter 5).
Chapter 2

Literature Review
2.1 Introduction
There is an extensive and continually advancing body of evidence that demonstrates the efficacy of physical activity in the prevention and management of type 2 diabetes mellitus (T2DM) (Boulé et al., 2001; 2003; Sigal et al., 2004; Kelley and Kelley, 2007; Chudyk and Petrella, 2011; Umpierre et al., 2011). Summarising the evidence the importance of regular exercise has been emphasised in a joint position statement released in December 2010 by the American College of Sports Medicine (ACSM) and the American Diabetes Association (ADA) which provides new guidelines on physical activity and exercise for people with T2DM (Colberg et al., 2010). However, in practice, the implementation of physical activity for effective diabetes management is still in its infancy and many with this chronic disease do not become or remain active (Morrato et al., 2007).

A confounding feature of literature pertaining to physical activity are the number of terms are used to define physical activity including, ‘exercise’, ‘sport’, ‘recreation’, ‘occupational activity’ and ‘household chores’ (Shephard, 2003). Bouchard and Shephard (1994) suggest physical activity comprises all types of muscular activity that increase energy expenditure substantially. Within physical activity sub-sets of activity exist which can be defined by other terms, such as exercise, defined as “exercise is a regular and structured subset of physical activity, performed deliberately and with special purpose such as preparation for athletic competition or the improvement of some aspect of health” (Shephard, 2003, p.197). In this literature review the term exercise will be used when describing structured supported or supervised intervention-based activity, while the broader term, physical activity, will be used in recognition of the many types of unsupported or unsupervised muscular activity that may have a positive effect on health status among individuals with T2DM.

The aim of this literature review is to provide an overview of T2DM and its management focusing on the evidence surrounding the importance of physical activity in the management of the condition. Various theories, models and research addressing self-management behaviour and motivation for physical activity behaviour will also be critically reviewed.
2.2 Pathology of type 2 diabetes mellitus

T2DM or non-insulin-dependant diabetes mellitus (NIDDM) accounts for approximately 80-90\% of all diabetes in most countries (McCarty and Zimmet, 1994) and is associated with hyperinsulinemia resulting from a reduction in insulin action in the liver and skeletal muscle (i.e. insulin resistance). The disease remains a particularly heterogeneous disorder: 5-10\% of patients may have maturity onset diabetes of youth (MODY) (Fajans, 1989); 5-10\% may have latent adult-onset autoimmune diabetes (Niskanen et al., 1995); and another 5-10\% may have diabetes secondary to genetic disorders (Gerbitz et al., 1996). The aetiology of the disease in the remaining 75-80\% of patients remains poorly defined and controversial (Gerich, 1998).

Although the pathogenesis of T2DM is contentious, it is commonly accepted that: 1) the disease has strong genetic and environmental (acquired) components (Yki-Järvinen, 1995); 2) its inheritance is polygenic (Turner et al., 1995), whereby the simultaneous presence of several abnormal genes or polymorphisms is necessary for the disease to develop; 3) impairment of insulin sensitivity and insulin secretion are important elements in its pathogenesis (DeFronzo, 2004); and 4) obesity, in particular intra-abdominal obesity engenders insulin resistance (Kahn and Flier, 2000). What is disputed are: 1) the steps that lead to the development of T2DM; 2) the quantitative contribution of insulin resistance and impaired insulin secretion; and 3) the major sites of insulin resistance (liver vs. muscle vs. adipose tissue vs. kidney) – a central issue in the ongoing management of T2DM (Gerich, 1998; Kahn, 2003).

Tuomilehto et al. (2001) has demonstrated that obesity and physical inactivity are among the main environmental determinants of the T2DM. During progression of the disease the β-cells of the pancreas compensate for insulin resistance by increasing insulin secretion. If insulin resistance persists hyperinsulinemia will follow. Hyperinsulinemia will remain until the β-cells can no longer suppress glucose production by the liver and compensate for the inability of skeletal muscle to take up glucose, resulting in hyperglycaemia (DeFronzo, 2004). Failure to appropriately manage hyperglycaemia can result in serious medical complications, which include: retinopathy, neuropathy, nephropathy, peripheral vascular disease, atherosclerotic cardiovascular and cerebrovascular disease, hypertension and susceptibility to
infection (Albright et al., 2000). A further impediment to appropriate management is that individuals with T2DM can remain asymptomatic for many years before clinical diagnosis (Harris et al., 1992).

### 2.3 The management of type 2 diabetes mellitus

Following diagnosis, the management of T2DM continues over an individual’s lifetime. According to the ADA (2010) the goal of diabetes management is to achieve and maintain optimal blood glucose (i.e. ‘good glycaemic control’ of HbA₁c ≤7.0%), lipid and blood pressure levels to prevent or delay complications of diabetes. Studies have shown the prevention and/or delay of the onset of diabetes related complications among individuals with T2DM is achievable. The most comprehensive study to date is the United Kingdom Prospective Diabetes Study (UKPDS); a 20-year trial which recruited 5,102 patients with T2DM in 23 clinical centres based in England, Scotland, and Northern Ireland (UKPDS Study Group, 1998). One of the major aims of the UKPDS was to quantify the relationship between blood glucose control and the relative risk of diabetes related complications. The UKPDS demonstrated that diabetes management programmes, on average, had a modest but clinically significant effect on glycaemic control of 0.9% reduction in HbA₁c (95% CI) over 10 years (Turner et al., 1999) with later studies showing similar results (Norris et al., 2002; Knight et al., 2005). The results also demonstrated that each 1% reduction in HbA₁c over 10 years was associated with a 21% reduction in risk for any end-point related to diabetes (Stratton et al., 2000).

In theory results evidenced by the UKPDS could and should be achievable by all those with T2DM. For instance, despite the UKPDS being a clinical research trial, a large, heterogeneous sample were recruited, participants were enrolled and managed in a wide variety of community clinics, and while the professionals conducting the study and directing care were very knowledgeable about diabetes, the overall treatment programme was not unusually sophisticated or complex (ADA, Position Statement, 2002). Yet a number of important observations should be acknowledged. The UKPDS was originally designed as a straightforward randomized clinical trial comparing the effects of an intensive treatment policy with four pharmacological monotherapies, versus a diet control group, on the cardiovascular and microvascular complications of T2DM. Upon commencement of the UKPDS participants had an
average HbA$_1c$ level of 9.1%. The conventional treatment group achieved a 10-year average HbA$_1c$ level of 7.9% and the intensive treatment group, with readily available glucose lowering agents, achieved an average HbA$_1c$ level of 7.0%. The initial treatment goal in all the intensive pharmacotherapy groups was a fasting plasma glucose (FPG) level $<$6.0 mmol·l$^{-1}$ and the treatment goal in the conventional diet control group was an FPG level $<$15 mmol·l$^{-1}$. These widely different treatment targets were meant to ensure attainment of adequate glycaemic separation to test the main research question - was lowering blood glucose beneficial? However, it became apparent that none of the oral pharmacological monotherapies were capable of maintaining the intensive treatment goal, and thus, combination therapy was used, mixing insulin or metformin with sulfonylureas, as well as crossing over patients into the alternate pharmacological treatment groups. Further, the diet group also became tainted, as participants in this group were treated with the same pharmacological agents used in the other groups if their FPG exceeded a level of 15 mmol·l$^{-1}$. Ultimately, 80% of the participants in the diet group (which served as the control) required one or more pharmacological agents reflecting the progressive nature of the disease.

Important conclusions can be drawn from these observations: 1) there is an increase in blood glucose levels with increasing duration of T2DM – a trend noted in both the conventional and intensive treatment groups of the UKPDS, and 2) there is a need for long-term persistence pharmaceutical intervention to achieve clinical success. These observations have important ramifications for interventions, particularly those which focus on diet and physical activity in the management of T2DM. The potential benefits of such interventions must be considered in light of the progressive nature of the disease and the importance of multiple pharmaceutical agents to achieve clinical treatment goals as evidenced by the UKPDS.

2.3.1 Approaches to diabetes management

The traditional perspective that healthcare professionals dictate diabetes care was derived within an ‘acute-care paradigm’ or the notion that modern medicine can ‘cure’ or ‘fix’ acute illness, disease and disability (Lorig and Holman, 2003). While the acute-care approach may effectively ameliorate many acute conditions, such healthcare delivery does not adequately address the needs of individual people or
populations with a long-standing, chronic condition such as T2DM (Norris et al., 2002). While it has been argued that traditionally the patient has been seen as ‘the problem’ (Anderson and Funnell, 2005), current thought suggests that effective diabetes care requires patients and healthcare professionals to collaborate and to combine the care-professional’s clinical experience with the concerns, value hierarchies and resources of the patient. Such collaboration and patient enablement is emergent from within an ‘empowerment paradigm’ (Lorig and Holman, 2003; Anderson and Funnell, 2005). Krichbaum et al. (2003) suggest people with diabetes administer around 95% of their own care. The empowerment approach simply recognises that patients are responsible for and in control of their important diabetes management decisions (such as appropriate medication adherence, dietary and physical activity choices), and it follows logically that the consequences of these decisions and choices also rest with the patient. The empowerment approach also acknowledges the importance of the individual and as a result does not automatically align itself with a one size fits all approach to diabetes care. From a physical activity perspective, the empowerment approach may prove invaluable to the ongoing development of T2DM care strategies particular given the heterogeneous nature of the condition and the considerable individual differences in response to exercise as highlighted by Rankinen and Bouchard (2008).

2.3.2 Self-management

The term self-management, as it is used throughout this thesis, attributes the patient with an ‘active participant’ role in treatment. The self-management construct emerged in the 1970s in the context of paediatric asthma research (Creer et al., 1976), and was based in part on the early works of Albert Bandura. Bandura (1986) attributes the patient an ‘active participant’ role in his or her own treatment, which invariably involves a plethora of personal choices which collectively impact on a person’s health status. T2DM is a self-managed illness in which the decisions most affecting the health and well-being of patients are made by the patients themselves, and these decisions are embedded in the routine activities of every day living.

Diabetes self-management comprises three distinct management tasks; 1) medical management (such as taking medication, adhering to a specific diet or physical activity programme), 2) role management (creating new meaningful behaviours or life
roles), and 3) emotional management (learning to adapt emotionally to a chronic condition which may alter the individuals view of the future) (Corbin and Strauss, 1988; Lorig and Holman, 2003). Specific to self-management and patient empowerment the importance of lifestyle factors – diet and physical activity – have been emphasised as central components of management for diabetes as a chronic condition (Glasgow et al., 2001). Key to achieving good glycaemic control is a patient’s motivation to perform self-management behaviours such as monitoring diet, performing physical activity, taking medication and testing blood glucose levels. However, these necessary behaviours all vie with one another as well as compete with life’s other motivations, behaviours and demands (Collins et al., 2009).

Despite evidence from studies such as the UKPDS (1998) and movement toward patient-centred approaches to diabetes management, Griffin et al. (1998) suggests only 7% of adults with T2DM follow all of the self-management behaviours (for example, seeking medical care, adherence to prescribed medication, dietary modifications and physical activity regimes) as prescribed to them by healthcare professionals. Following review of seven meta-analyses and 57 published controlled trials of educational and psychosocial interventions Griffin and colleagues concluded many interventions fail to address the psychosocial and emotional aspects of disease management (Griffin et al., 1998). Gonder-Frederick et al. (2002) suggests a prime reason for low levels of self-management behaviours among T2DM populations is that many interventions remain grounded in the acute-care paradigm. Such interventions have sought to address the problem of patient non-compliance to prescribed care regimes, by attempting to implement strategies that simply focus on the non-compliance issue, with little consideration of the wider context.

2.3.2.1 Self-management and physical activity
The joint position statement from the ACSM and ADA (Colberg et al. 2010) recommends at least 150 min·week$^{-1}$ of aerobic exercise of at least moderate intensity – activities such as brisk walking is acknowledged as a moderate-intensity aerobic exercise that is appropriate for most people with T2DM. Aerobic exercise should be spread over at least 3 days·week$^{-1}$ with no more than two consecutive days between bouts of aerobic activity. The recommendations also acknowledges the benefits of resistance exercise and as such, recommends that, in addition to the aerobic activity
requirements, resistance exercise of at least moderate or vigorous intensity should be undertaken at least twice weekly on non-consecutive days, but ideally three times·week$^{-1}$ (Colberg et al., 2010). The guidelines may reflect what we already know - physical activity is beneficial for those with T2DM - however, the guidelines provide patients with T2DM and those who care for them with evidence that reflects an increased understanding of the relationship between physical activity and T2DM resulting from the studies conducted in the area over the past decade (discussed in Sections 2.4 and 2.5). Despite the progress which has been made Kavookjian et al. (2007) suggests of the self-management behaviours affecting glycaemic control and prevention of diabetes complications, the lifestyle behaviour of physical activity remains the most problematic. Whilst Plotnikoff et al. (2011a) suggests 70% of patients with T2DM still do not achieve the recommended guidelines for physical activity. Health behaviour theories and models with emphasis on the individual are being used more widely in an attempt to address the problem of physical inactivity among this population and are discussed in Section 2.7.

2.4 Exercise and type 2 diabetes mellitus

The following section focuses on the physiological effects of exercise reviewing evidence surrounding the implications of exercise in the management of T2DM.

2.4.1 Physiological mechanisms associated with exercise

Among older adults the associated benefits of physical activity and exercise include the following:

1) a more favourable body composition - less total and abdominal body fat (Going et al., 1995; Holloszy and Kohrt, 1995), greater relative muscle mass (% of body mass) in the limbs (Sugawara et al., 2002), and higher bone mineral density at weight bearing sites (Goodpaster et al., 1996; Mussolino et al., 2001)

2) greater oxidative and fatigue-resistant limb muscles (Holloszy and Kohrt, 1995; Proctor et al., 1995; Trappe et al., 1996)

3) higher capacity to transport and use oxygen (Ogawa et al., 1992; Proctor et al., 1998)

4) higher cardiac stroke volume at peak exertion (Goldspink, 2005)

5) less cardiovascular (Hagberg et al., 1985) and metabolic (Coggan et al., 1993) stress during exercise at any given submaximal work intensity
6) significantly reduced coronary risk profile (lower blood pressure, increased HR variability, better endothelial reactivity, lower systemic inflammatory markers, better insulin sensitivity and glucose homeostasis, lower triglycerides, LDL, and total cholesterol, higher HDL, and smaller waist circumference) (Williams, 1998)
7) slower development of impaired mobility in old age (Wang et al., 2002)

2.4.1.1 Acute effects of exercise
During aerobic exercise fuel mobilisation is predominantly controlled by the neuroendocrine system (Suh et al, 2007). Typically, blood glucose levels are maintained by glucose production via liver glycogenolysis and gluconeogenesis and mobilisation of alternate fuels, such as free fatty acids (Wahren and Ekberg, 2007). However, contracting muscles increase the uptake of blood glucose, and driven by exercise fuel availability a decrease in insulin secretion and increases in glucagon, catecholamines, cortisol secretion, and other hormones are observed (Koyama et al., 2001; Wahren and Ekberg, 2007).

While other parameters such as shifts in blood-flow and changes in glycaemia or metabolic state play a role in the control of fuel metabolism during exercise (Sigal et al., 2004) the most important are the intensity and duration of physical activity (Sigal et al., 2004). Early in exercise, glycogen provides the bulk of the fuel for working muscles. As glycogen stores become depleted, muscles increase their uptake and use of circulating blood glucose, along with free fatty acids released from adipose tissue (Kang et al., 1999; Watt et al., 2002). Intramuscular lipid stores are more readily used during longer-duration activities and recovery (Wang et al., 2009). Moderate-intensity exercise is associated with an approximately 10-fold increase in fat oxidation due to increased energy expenditure coupled with greater fatty acid availability. The increase in fatty acid availability is due both to an increase in lipolysis and decreased re-esterification of NEFA to triglycerides (Wasserman and Cherrington, 1996).

2.4.1.2 Endogenous glucose production
With increasing exercise intensity, there is a greater reliance on carbohydrate as long as sufficient amounts are available in muscle or blood (Kang et al., 1996; Boon et al., 2007). During very intense aerobic exercise (≥80% of VO₂max), the catecholamines
levels - norepinephrine and epinephrine - rise as much as 15-fold from baseline, and glucose production rises about 7-fold during exercise (Kreisman et al., 2003).

Muscle glucose uptake requires three serial steps:

1) Glucose delivery from blood to muscle: During exercise muscle interstitial glucose falls precipitously leading to an insufficient glucose transport gradient which is unable to sustain glucose uptake if it were not for the increase in blood flow to working muscle. The exercise-induced increase in glucose delivery via increased blood flow is so effective that an increase in muscle fractional glucose extraction is not required for the increase in muscle glucose uptake and maintaining muscle interstitial glucose (Hargreaves et al., 1991).

2) Membrane glucose transport: Exercise increases glucose transport by stimulating GLUT4 translocation to the muscle cell surface (Sigal et al., 2004). A possible mechanism involves sensing of an increase in muscle AMP, which stimulates AMP kinase, causing a number of metabolic changes, including increased glucose transport (Kemp et al., 1999). Such a role for this enzyme is supported by the demonstration that pharmacological activation of AMP kinase stimulates GLUT4 translocation (Kurth-Kraczek et al., 1999) and glucose uptake (Mu et al., 2001) and is linked to other changes in enzyme activities (Saha et al., 2000) and gene transcription (Zheng et al., 2001) associated with exercise.

3) Muscle glucose phosphorylation: The first step in glucose metabolism is phosphorylation by a hexokinase. There is evidence that glucose phosphorylation is the primary limitation to glucose uptake during exercise (Halseth et al., 1999). In contrast to the extensive work on glucose transport, very little is known regarding the effects of exercise on hexokinases.

2.4.1.3 Insulin-independent and insulin sensitive muscle glucose uptake during exercise

Exercise increases both insulin-independent muscle glucose uptake and insulin sensitivity.

Insulin-independent glucose uptake: Although the increase in membrane transporters in response to both insulin and exercise result from an increase in GLUT4 translocation, these stimuli recruit GLUT4 from different intracellular pools (Coderre et al., 1995). Evidence that cell signalling for glucose uptake is different for exercise
and insulin is supported by the demonstration that muscle contraction does not increase phosphorylation of insulin receptor substrate (IRS)-1 and -2 or phosphatidylinositol I (PI) 3-kinase which are involved in insulin signalling (Goodyear et al., 1995). The importance of insulin-independent mechanisms in control of exercise-stimulated muscle glucose uptake is further exemplified by studies in among diabetics. Although T2DM individuals are usually insulin resistant, they are not resistant to the stimulatory effects of exercise on glucose utilisation. Individuals with T2DM also retain the ability to translocate GLUT4 to the sarcolemma in response to exercise (Kennedy et al., 1999).

Insulin-dependent glucose uptake (insulin sensitivity): The primary route of insulin mediated glucose metabolism at rest and in the postexercise state is nonoxidative metabolism (Wasserman and Cherrington, 1996). Exercise, however, shifts the route of insulin-stimulated glucose disposal so that all glucose consumed by muscle is oxidised (Wasserman and Cherrington, 1996). Several mechanisms have been proposed to explain how exercise enhances insulin action (Ivy et al., 1999) Hemodynamic adjustments increase capillary surface area in working muscle, increasing the availability of insulin.

2.4.1.4 Postexercise glucose metabolism

Exercise leads to diverse adaptations that have significant impact on glucoregulation, even after the cessation of exercise. These adaptations largely share the common purpose of replenishing fuel stores, particularly muscle and liver glycogen (Sigal et al., 2004). Glucose uptake after exercise is characterised by a marked and persistent increase in insulin action (Richter, 1996) which can persist even when pre-exercise glycogen levels have been restored. The cellular basis for the persistent increase in insulin sensitivity may, at least in part, relate to increases in skeletal muscle GLUT4 (Ren et al., 1994), glycogenin (Kraniou et al., 2000), and hexokinase II (O’Doherty et al., 1994) during exercise recovery.

The adaptation of the pancreatic β-cell to exercise training has also been assessed. Basal and glucose-stimulated insulin levels are both reduced in response to regular exercise due to reduced secretion (Wasserman and Cherrington, 1996). Training results in decreases in the mRNA for proinsulin and glucokinase in the pancreas.
(Koranyi et al., 1991) suggesting there are at least two potential cellular mechanisms for decreased insulin secretion; 1) reduction in proinsulin mRNA suggests that the synthesis of insulin is reduced, and 2) as glucokinase is necessary for glucose sensing in the pancreas, the reduction in glucokinase mRNA may explain the decreased sensitivity of the β-cell to glucose.

Another key aspect of improved insulin action is fat oxidation, and training increases lipid storage in muscle and fat oxidation capacity (Kelley and Kelley, 2007). An individual’s training status will also affect fuel utilisation during aerobic activity. Aerobic training increases fat utilisation during a similar duration bout of low- or moderate-intensity activity done after training, which spares muscle glycogen and blood glucose and results in a lesser acute decrease in blood glucose (Pruchnic et al., 2004). Trained subjects also have an increased ability to mobilise and store NEFAs (Romijn et al., 1993). The increased ability to mobilise NEFAs occurs at least in part due to increased adipocyte catecholamine sensitivity and is mediated by an increased formation and/or improved effectiveness of cAMP (Izawa et al., 1991). Training increases the capacity of muscle to extract NEFAs from the blood and oxidise them, which may reflect an enhanced capacity of trained muscle to oxidise fat (Schrauwen et al., 2002) or to increased number or function of muscle fatty acid transport or binding proteins (Tunstall et al., 2002).

2.4.2 **The effects of aerobic exercise in type 2 diabetes mellitus**

Dela et al. (2004) investigated effects of aerobic training on β-cell function in type 2 diabetic patients. T2DM patients stratified into "moderate" and "low" secretors according to individual C-peptide responses to a glucose challenge were randomly assigned to a training programme (ergometer cycling 30–40 min·day⁻¹, including a minimum of 20 minutes at 75% VO₂max, 5 days·wk⁻¹ for 12-weeks) or a sedentary schedule. Exercise training increased VO₂max 17[13]% and decreased heart rate during submaximal exercise (P<0.05). During 12-weeks of sedentary lifestyle, insulin and C-peptide responses were unchanged in both moderate and low secretors. Likewise, no change in β-cell response was seen after training in the low secretors (n=5). In contrast, moderate secretors (n=9) showed significant increases in β-cell responses but measures of insulin sensitivity and HbA₁c levels were not altered by aerobic training. The study suggests that in order for exercise training to enhance β-cell function there
must be (moderate) remaining secretary capacity. This may well limit some of the potential benefits exercise can offer those with long-term diabetes, but emphasizes the prominent role exercise could play for individuals recently diagnosed with T2DM. There is currently a paucity of evidence investigating the effect of exercise among newly diagnosed T2DM patients.

Bjørgaas et al. (2005) investigated the relationship between pedometer-registered activity, aerobic capacity (VO\(_{2}\text{max}\)) and self-reported activity and fitness in patients with T2DM before and after a 12-week exercise programme. Twenty-nine men with type 2 diabetes (age=57.4 [7.8] years, body mass index [BMI]=31.7 [2.8] kg\(\cdot m^2\)) were randomized to an exercise (E) group (n=15) or a control (C) group (n=14). Participants in E group were offered supervised exercise twice a week for 12 weeks. Both E and C groups tended to increase pedometer activity. In E group, body mass decreased by 2.7% (P=0.01), VO\(_{2}\text{max}\) increased 10.6% (P=0.03) and HbA\(_1c\) decreased by 5.2% from baseline (P=0.02). In E group, an increase in pedometer activity correlated with a fall in HbA\(_1c\) (r=0.84, P<0.01) and in diastolic blood pressure (r=0.77, P=0.025).

O’Donovan et al. (2005) investigated the effect of exercise intensity on insulin resistance by comparing moderate- and high-intensity interventions of equal energy cost. VO\(_{2}\text{max}\), insulin, glucose and TG were measured in 36 T2DM men before randomisation to a non-exercise control group (n=13), a moderate-intensity exercise group (3, 400-kcal sessions·week\(^{-1}\) at 60% of VO\(_{2}\text{max}\)) (n=10) or a high-intensity exercise group (3, 400-kcal sessions·week\(^{-1}\) at 80% of VO\(_{2}\text{max}\)) (n=13) for 24 weeks. Insulin concentration decreased by 2.54[4.09] and 2.37[3.35] mU l\(^{-1}\), insulin sensitivity score increased by 0.91[1.52] and 0.79[1.37], and HOMA\(_{IR}\) decreased by -0.6[0.8] and -0.5[0.8] in the moderate- and high-intensity exercise groups, respectively. Changes in insulin concentration, insulin sensitivity score and HOMA\(_{IR}\) were not significantly different between the exercise groups but significantly greater than those observed in the control group (all P<0.05) suggesting that moderate-intensity exercise was as effective as high-intensity exercise when 400 kcal are expended per session.
Coker et al. (2006) examined the influence of moderate-intensity (50% of VO$_{2\text{max}}$) exercise training vs. high-intensity (75% of VO$_{2\text{max}}$) exercise training on insulin-stimulated glucose disposal (ISGD) in elderly individuals. Twenty-one overweight (body mass index = 29[1.0] kg·m$^{-2}$) elderly (74[1.0] years) completed a 12-week exercise training regimen designed to expend 1000 kcal·wk$^{-1}$. ISGD increased by approximately 20% with high-intensity but no change was observed with moderate-intensity. Non-oxidative glucose disposal increased with high-intensity but there was no change with moderate-intensity. No change in body mass or percentage of body fat was observed in either group. In contrast to the findings of O’Donovan et al. (2005), Coker et al. (2006) concluded in weight-stable participants, moderate-intensity exercise resulted in no change in ISGD, and the improvement in ISGD with high-intensity exercise was completely reliant on improvements in non-oxidative glucose disposal.

Kadoglou et al. (2010) sought to investigate the effects of rosiglitazone and/or exercise training on cardiovascular risk factors in patients with T2DM. One hundred T2DM patients, with HbA$_{1c}$ >7% despite combined treatment with gliclazide plus metformin, were randomized using a 2 x 2 factorial design to 4 equivalent (n=25) groups, as follows: (1) CO: maintenance of habitual activities, (2) RSG: add-on therapy with rosiglitazone (8 mg·d$^{-1}$), (3) EX: exercise training, and (4) RSG + EX: supplementary administration of rosiglitazone (8 mg·d$^{-1}$) plus exercise training. Participants were free of diabetic vascular complications and were not in receipt of any lipid-lowering therapy. Anthropometric parameters, cardiorespiratory capacity, glycaemic and lipid profile, apolipoprotein (apo) A-I, apo B, interleukin (IL)-10, IL-18, insulin resistance, and blood pressure were measured before and after 12 months of intervention (P<0.05). Both RSG and EX groups significantly reduced glycaemic indexes, insulin resistance, blood pressure, and IL-18, whereas they significantly increased high-density lipoprotein (HDL), cardiorespiratory capacity, and IL-10, compared with CO group (P<0.05). Further, among exercise-treated patients a down-regulation in other lipid parameters (total cholesterol [TC], low-density lipoprotein [LDL] cholesterol [-C], triglycerides [TG], apo B) and body fat content (P<0.05) in comparison with CO group was observed. Whereas, RSG group in comparison to the CO group considerably increased apo A-I levels and body mass index (P<0.05). The combined treatment group yielded pronounced beneficial changes in glycaemic
indexes, lipid profile, insulin resistance, blood pressure, IL-10, IL-18, apo A-I, and apo B (vs. CO group, P<0.05). Furthermore, the addition of exercise to rosiglitazone treatment counteracted the drug-related negative effects on body weight, LDL-C, and TC. Rosiglitazone plus exercise training elicited additive effects on body composition, glycaemic control, traditional and novel cardiovascular risk factors in T2DM patients, indicating complementary effects. The Kadoglou and colleagues study represents the potential benefits of exercise for those with less than optimal glycemic control who are in receipt of pharmaceutical agents.

Outcomes of studies investigating aerobic exercise among patients with T2DM suggests moderate to high intensity activity (60-80% VO\textsubscript{2}max) can provide numerous benefits to patients including improved glycaemic control, lipid profile and body composition (Bjørgaas et al., 2005; O’Donovan et al., 2005; Kadoglou et al., 2010). Evidence from Kadoglou et al. (2010) also suggests the benefits of exercise may counteract the detrimental effects of some pharmaceutical agents which further emphasises the vital role exercise can play in the continual management of this chronic condition. More research is required to investigate the effect of exercise in those newly diagnosed with T2DM, for whom, in view of Dela and colleagues 2004 findings, exercise may offer potentially greater benefits in comparison to those with established long-term T2DM.

### 2.4.3 The effects of resistance exercise in type 2 diabetes mellitus

Dunstan et al. (2002) randomized 36 sedentary, T2DM participants aged 60-80 years to 6 months of moderate weight loss plus high-intensity resistance training (RT/WL group; progressing to three sets of 8-10 repetitions of 8-10 exercises three times per week at 75-80% of maximum) or moderate weight loss plus flexibility exercise (control/WL group). Absolute HbA\textsubscript{1c} declined 1.2% in the RT/WL group compared with just 0.4% in the control/WL group (P<0.05 between groups). Mean weight loss and fat loss were similar in both groups, but mean lean body mass increased by 0.5 kg in RT/WL participants while decreasing 0.4 kg in control/WL participants (P<0.05 between groups). Castaneda et al. (2002) randomized 62 older sedentary adults (40 women and 22 men; mean age 66 years) to 16 weeks of individually supervised high-intensity resistance exercise (RT group, progressing to three sets of eight repetitions of five exercises three times·week\textsuperscript{-1} at 70–80% of maximum) or sedentary control.
Mean HbA1c declined from 8.7 to 7.6% in RT but did not change in control participants (P=0.01 between groups), even though 72% of RT participants (vs. 3% of control participants) had hypoglycaemic medications reduced and 42% of control participants (vs. 7% of RT participants) had hypoglycaemic medications increased. Mean systolic blood pressure declined 9.7 mmHg in RT participants and rose 7.7 mmHg in control participants (P=0.05 between groups). Free fatty acid concentrations declined significantly by 27% in the RT group compared with control participants, in whom circulating free fatty acids increased by 10%. In the RT group muscle glycogen storage increased by 31% and a mean increase in lean tissue mass of 1.2 kg was observed. There were no differences in other cardiovascular risk factors such as high-density lipoprotein cholesterol (HDL-C), LDL-C and TC levels. The control group which exhibited no change in HbA1c also demonstrated a 23% reduction in muscle glycogen storage.

Ibanez et al. (2005) evaluated the influence of a twice-weekly progressive resistance training programme, without a concomitant weight loss diet, on abdominal fat and insulin sensitivity in older men with T2DM. Nine older men (aged 66.6 [3.1] years) with T2DM participated in a 16-week progressive resistance training supervised programme (50-80% of the one repetition maximum), for all main muscle groups. Measurements were taken 4 weeks before training (-4), immediately before training (0), and at 8-week intervals (i.e., weeks 8 and 16) during the 16-week training period. No significant variation was observed in any of the above selected parameters during the 4-week control period. After progressive resistance training, both leg and arm maximal strength increased significantly by 17.1 and 18.2%, respectively. Visceral and subcutaneous abdominal fat decreased significantly by 10.3% (from 249.5 [97.9] to 225.6 [96.6] cm³, P<0.01) and by 11.2% (from 356.0 [127.5] to 308.6 [118.8] cm³, P<0.01), respectively, while no changes were observed in body mass. Progressive resistance training significantly increased insulin sensitivity by 46.3% (from 2.0 [1.2] to 2.8 [1.6] 10⁴.min⁻¹.muU⁻¹.ml⁻¹, P<0.01), whereas it significantly decreased (-7.1%, P<0.05) fasting blood glucose (from 146.6 [28.3] to 135.0 [29.3] mg·dl⁻¹). Finally, a 15.5% increase in energy intake (from 2,287.1 [354.7] to 2,619.0 [472.1] kcal·day⁻¹, P<0.05) was observed. Abdominal adiposity has also been linked to insulin resistance (Kahn and Flier, 2000) and thus the findings may suggest another mechanism to explain the positive effects of resistance training on insulin resistance. However,
given the small sample size and uncontrolled study design of the Ibanez et al. (2005) study, care should be taken in interpreting these findings.

Dunstan et al. (2005) performed a 12-month randomized controlled trial in 36 sedentary, overweight men and women with T2DM (aged 60-80 years) who were randomly assigned to moderate weight loss plus high-intensity progressive resistance training (RT+WL group) or moderate weight loss plus a control programme (WL group). Supervised gymnasium-based training as described in Dunstan et al. (2002) for 6 months was followed by an additional 6 months of home-based training. HbA\textsubscript{1c}, body composition, muscle strength, and metabolic syndrome abnormalities were assessed at 0, 3, 6, 9, and 12 months. Compared with the WL group, HbA\textsubscript{1c} decreased significantly more in the RT+WL group (-0.8%) during 6 months of supervised gymnasium-based training; however, this effect was not maintained after an additional 6 months of home-based training. In contrast, the greater increase in lean body mass (LBM) observed in the RT+WL group compared with the WL group (0.9 kg, P<0.05) after the gymnasium-based training tended to be maintained after the home-based training (0.8 kg, P=0.08). Similarly, the gymnasium-based increases in upper body and lower body muscle strength in the RT+WL group were maintained over the 12 months (P<0.001). There were no between-group differences for changes in body weight, fat mass, fasting glucose, or insulin at 6 or 12 months. The authors concluded that among older adults with T2DM, home-based progressive resistance training was effective for maintaining the gymnasium-based improvements in muscle strength and LBM but not glycaemic control. Reductions in adherence and exercise training volume and intensity would appear to impede the effectiveness of home-based training for maintaining improved glycaemic control.

In a follow-up to the 2005 study Dunstan et al. (2006) investigated whether beneficial effects on glycaemic control of an initial laboratory-supervised resistance training programme (Dunstan et al., 2005) could be sustained through a community centre-based maintenance programme. 57 overweight (BMI ≥ 27 kg·m\textsuperscript{-2}) sedentary men and women aged 40-80 years with established (>6 months) T2DM initially attended a twice-weekly 2-month supervised resistance training programme conducted in the exercise laboratory. Thereafter, participants undertook a resistance training maintenance programme (twice-weekly) for 12 months and were randomly assigned
to carry this out either in a community fitness and recreation centre or at home. HbA$_{1c}$ was assessed at 0, 2, and 14 months. Combining data from the two groups for the 2-month supervised resistance training programme showed that compared with baseline, mean HbA$_{1c}$ fell by -0.4% [95% CI -0.6 to -0.2]. Within-group comparisons showed that HbA$_{1c}$ remained lower than baseline values at 14 months in the centre group (-0.4% [-0.7 to -0.03]) but not in the home group (-0.1% [-0.4 to 0.3]). However, no between-group differences were observed at each time point. Changes in HbA$_{1c}$ during the maintenance period were positively associated with exercise adherence in the centre group only. Dunstan and colleagues concluded that centre-based but not home-based resistance training was associated with the maintenance of modestly improved glycaemic control from baseline, which was proportional to programme adherence.

The interventions undertaken by Dunstan et al. (2002) and Castaneda et al. (2002) involved high exercise intensity (70-85% of one repetition maximum vs. 40-60% of one repetition maximum) and three sets of each exercise. Another important finding of Castaneda et al. (2002) was that diabetes specific medications were reduced by 72% for individuals in the resistance-trained group when compared with 3% decrease in the control group. Evidence from Dunstan et al. (2002) and Castaneda et al. (2002) suggest that increases in skeletal muscle mass are related to decreases in HbA$_{1c}$ and support the hypothesis that resistance training improves glycaemic control by increasing the skeletal muscle storage of glucose. Although it is still not clear, if this effect is due to an increase in muscle size and/or qualitative changes of certain muscular functions, the findings from both Dunstan et al. (2005) and Dunstan et al. (2006) suggest supervision as well as continued support or supportive environments to promote exercise maintenance is vital to achieving and maintaining exercise related benefits.

2.4.4 Combined aerobic and resistance exercise

Whether combined resistance and aerobic training offers a synergistic and incremental effect on glycaemic control in individuals with T2DM has been addressed by a number of studies (Cuff et al., 2003; Balducci et al., 2004; Tokmakidis et al., 2004; Sigal et al., 2007; Church et al., 2010; Balducci et al., 2010).
Cuff et al. (2003) randomized 28 well-controlled, obese, postmenopausal type 2 diabetic women to combined aerobic and resistance training, aerobic training alone, or a non-exercising control group for 16 weeks. Participants in the exercising groups participated in three 75-min gym sessions·week$^{-1}$ at 60-75% of heart rate reserve, whereas the resistance training programme included two sets of 12 repetitions of five exercises. HbA$\text{1c}$ was excellent in all groups before training (6.3–6.9%) and did not change with exercise training. However, insulin sensitivity assessed increased significantly more in the combined aerobic and resistance exercise group than in the aerobic exercise only or control groups. Body fat declined significantly and similarly in both exercise groups, but muscle mass increased significantly only in the combined aerobic and resistance exercise group. Cuff et al. (2003) were the first to compare combined aerobic and resistance training with an aerobic only training group as well as a non-exercising control group. While both training regimes (combined and aerobic only) resulted in significant reductions in body mass and abdominal adiposity, only the combined group revealed improved insulin sensitivity, glucose disposal and a markedly greater increase in muscle density. Improved glucose disposal with training was significantly related to the reductions in abdominal subcutaneous and visceral adipose tissue. These findings are in contrast to those of Ibanez et al. (2005) and would suggest that improved glucose clearance was a result of both reduced visceral adiposity as well as enhanced muscle quality. Although Cuff et al. (2003) showed a lack of variations in HbA$\text{1c}$ values between the groups, the low average baseline HbA$\text{1c}$ (6.7%) and small sample (9-10 persons per group) may have limited the capacity to detect a difference.

Balducci et al. (2004) assigned 120 (60 men and 60 women) T2DM patients, aged 60.9 [8.9] years, with duration of diabetes 9.8 [7.3] years, to one of two treatments: 62 participants (30 men and 32 women) performed the aerobic plus resistance training (ART) programme, whereas 58 participants (30 men and 28 women) were asked to continue with their current diet and pharmacological therapy and forming the control group. The ART group performed 30-min of aerobic training at 40–80% of the heart rate reserve plus another 30-min resistance training programme at 40–60% of a single repetition maximal lift (1 RM), which was retested every 3 weeks. The workload was 12 repetitions each of six exercises selected for each major muscle group (i.e., legs, chest, shoulders, back, arms, and abdomen) for three sets, three sessions·week$^{-1}$ for 1
There were no significant differences between the two groups at baseline. After 1 year, the control group showed no statistically significant change in any measured parameters. The ART group, conversely, showed a statistically significant decrease in BMI (30.1 [5.6] to 28.8 [4.8] kg·m$^{-2}$, $P$ < 0.0001), waist circumference (103 [14] to 98 [12.7] cm, $P$ < 0.0001), fasting plasma glucose (FPG) (165 [60.6] to 129 [37] mg·dl$^{-1}$, $P$ < 0.0001), TC (212 [40.2] to 195 [35.4] mg·dl$^{-1}$, $P$ < 0.0001), LDL-C (130 [34.2] to 124 [28.7] mg·dl$^{-1}$, $P$ < 0.0001), TG (187 [109] to 146 [81] mg·dl$^{-1}$, $P$ < 0.0001), HbA$\text{c}$ (8.31 [1.73] to 7.1 [1.16]%, $P$ < 0.0001), systolic blood pressure (139 [17.1] to 135 [15.5] mmHg, $P$ < 0.04), and diastolic blood pressure (85.3 [8.8] to 81.3 [6.7] mmHg, $P$ < 0.0001) and a significant increase in fat-free mass (46.8 [11] to 47.2 [10.8] kg, $P$ < 0.0001) and HDL-C (43.6 [9.1] to 48.6 [12.1] mg·dl$^{-1}$, $P$ < 0.0001). The frequency of medication changes between the ART and control groups was not significantly different, however, a trend toward decreasing amounts of medications in all three classes of drugs (hypolipidemic, hypoglycaemic, and antihypertensive therapies) in the ART group was observed (-7.85, -3.94, and -5.90%, respectively), whereas in the control group, the opposite trend occurred (5.67, 7.55, and 5.67%, respectively). Throughout the study, no adverse effects occurred and a dropout rate of 17.7% was observed in the ART group suggesting that participants with T2DM are willing and able to participate in a demanding intervention programme if it is made available to them. Balducci et al. (2004) concluded a combination of aerobic and resistance training is well tolerated, feasible, and safe, and it improves glycaemic control, cardiovascular risk factors, and body composition in type 2 diabetic patients. Furthermore these findings also suggest that longer duration, more moderate resistance training may be as efficient as short-term high-intensity programmes at maintaining glucose homeostasis and reducing cardiovascular risk factors. However, some caution is required in the interpretation of these results, as study participants were allowed to select an exercise or non-exercise group and Balducci et al. (2004) did not report post-intervention change between-groups.

Tokmakidis et al. (2004) investigated short- and long-term effects of a combined strength and aerobic training programme on glycaemic control, insulin action, exercise capacity and muscular strength in postmenopausal women with T2DM. Nine postmenopausal women, aged 55.2 [6.7] years, with T2DM participated in a
supervised training programme for 4 months consisting of two strength training sessions (3 sets of 12 repetitions at 60% one-repetition maximum strength) and two aerobic training sessions (60-70% of maximum heart rate at the beginning, and 70-80% of maximum heart rate after 2 months). Measures were taken at baseline and at 4 and 16 weeks of the exercise programme. Significant reductions were observed in both the glucose (8.1% P<0.01) and insulin areas under the curve (20.7%, P<0.05) after 4 weeks of training. These adaptations were further improved after 16 weeks (glucose 12.5%, insulin 38%, P<0.001). HbA1c was significantly decreased after 4 weeks (7.7 [1.7] vs. 7.1 [1.3] %, P<0.05) and after 16 weeks (7.7 [1.7] vs. 6.9 [1.0] %, P<0.01) of exercise training. Furthermore, exercise time and muscular strength were significantly improved after 4 weeks (P<0.01) as well as after 16 weeks (P<0.001) of training. Body mass and BMI, however, were not significantly altered throughout the study. The results indicated that a combined training programme of strength and aerobic exercise could induce positive adaptations on glucose control, insulin action, muscular strength and exercise tolerance in women with T2DM.

The Diabetes Aerobic and Resistance Exercise (DARE study) by Sigal et al. (2007) sought to determine the effects of aerobic training alone, resistance training alone, and combined exercise training on HbA1c values in patients with T2DM. Sigal et al. (2007) performed a randomized, controlled trial utilising 8 community-based facilities. 251 adults aged 39-70 years with T2DM were required to adhere to exercise during a 4-week run-in period, before randomisation. Exercise training was performed 3 times·week<sup>−1</sup> for 22 weeks (weeks 5 to 26 of the study). The absolute change in the HbA1c value in the combined exercise training group compared with the control group was -0.51 % (95% CI, -0.87 to -0.14). Combined exercise training resulted in an additional change in the HbA1c value of -0.46 % (CI, -0.83 to -0.09) compared with aerobic training alone and -0.59 % (CI, -0.95 to -0.23) compared with resistance training alone. Changes in blood pressure and lipid values did not differ statistically among groups. Sigal et al. (2007) concluded either aerobic or resistance training alone improves glycaemic control in T2DM, but the improvements are greatest with combined aerobic and resistance training. However, a notable limitation of the study is that the total duration of exercise in the combined exercise training group was greater than that performed in the aerobic or resistance training alone groups.
Church et al. (2010) investigated the benefits of aerobic training alone, resistance training alone, and a combination of both on HbA$_{1c}$ in individuals with T2DM. In a randomized controlled trial 262 sedentary men and women with HbA$_{1c}$ levels of 6.5% or higher were enrolled in the 9-month exercise programme between April 2007 and August 2009. Forty-one participants were assigned to the non-exercise control group, 73 to resistance training 3·days·week$^{-1}$, 72 to aerobic exercise in which they expended 12 kcal·kg·week$^{-1}$; and 76 to combined aerobic and resistance training in which they expended 10 kcal·kg·week$^{-1}$ and engaged in resistance training 2·week$^{-1}$. The study included 63.0% women and 47.3% non-white participants who were 55.8 [8.7] years with a baseline HbA$_{1c}$ level of 7.7% (1.0%). Compared with the control group, the absolute mean change in HbA$_{1c}$ in the combination training exercise group was -0.34% (95% CI, -0.64% to -0.03%; P=0.03). The mean changes in HbA$_{1c}$ were not statistically significant in either the resistance training (-0.16%; 95% CI, -0.46% to 0.15%; P = 0.32) or the aerobic (-0.24%; 95% CI, -0.55% to 0.07%; P = 0.14) groups compared with the control group. Only the combination exercise group improved VO$_{2\text{max}}$ (mean, 1.0 ml·kg·min$^{-1}$; 95% CI, 0.5-1.5, P<0.05) compared with the control group. All exercise groups reduced waist circumference between -1.9 to -2.8 cm compared with the control group. The resistance training group lost a mean of -1.4 kg fat mass (95% CI, -2.0 to -0.7 kg; P<0.05) and combination training group lost a mean of -1.7 (-2.3 to -1.1 kg; P<0.05) compared with the control group. Church et al. (2010) suggested that among patients with T2DM, a combination of aerobic and resistance training compared with the non-exercise control group is needed to improve HbA$_{1c}$ levels. This was not achieved by aerobic or resistance training alone.

The Italian Diabetes Exercise Study (IDES) (Balducci et al., 2010) aimed to assess the efficacy of an intensive exercise intervention strategy in promoting physical activity and improving HbA$_{1c}$ level and other modifiable cardiovascular risk factors. 606 patients were enrolled in 22 outpatient diabetes clinics across Italy and randomized by center, age, and diabetes treatment to twice-a-week supervised aerobic and resistance training plus structured exercise counselling (exercise group) vs. counselling alone (control group) for 12 months. Physical activity levels (metabolic equivalent hours·week$^{-1}$) was significantly higher (P<0.001) in the exercise (total physical activity = unsupervised conditioning physical activity + supervised physical activity), (20.0 [0.9]), and unsupervised, (12.4 [7.4]) groups vs. control (10.0 [8.7]) group.
Compared with the control group, supervised exercise produced significant improvements (mean difference [95% confidence interval]) in physical fitness; HbA\textsubscript{1c} level (-0.30% [-0.49% to -0.10%]; P<0.001); systolic (-4.2 mmHg [-6.9 to -1.6 mmHg]; P=0.002) and diastolic (-1.7 mmHg [-3.3 to -1.1 mmHg]; P=0.03) blood pressure; HDL (3.7 mg·dL\textsuperscript{-1} [2.2 to 5.3 mg·dL\textsuperscript{-1}]; P<0.001) and LDL (-9.6 mg·dL\textsuperscript{-1} [-15.9 to -3.3 mg·dL\textsuperscript{-1}]; P=0.003) cholesterol level; waist circumference (-3.6 cm [-4.4 to -2.9 cm]; P<0.001); BMI; insulin resistance; inflammation; and risk scores. These parameters improved only marginally in controls. Balducci and colleagues concluded that the exercise intervention strategy was effective in promoting physical activity and improving HbA\textsubscript{1c} and cardiovascular risk profile. Conversely, counselling alone, though successful in achieving the currently recommended amount of physical activity, was of limited efficacy on cardiovascular risk factors, suggesting the need for a larger volume of physical activity among T2DM patients. Summaries of the reviewed exercise studies are displayed in Tables 2.1 and 2.2.
Table 2.1 Summary of exercise studies

<table>
<thead>
<tr>
<th>Author</th>
<th>Participants</th>
<th>W</th>
<th>S</th>
<th>T.M.</th>
<th>Programme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Castaneda et al. (2002)</td>
<td>62 (31E + 31C)</td>
<td>16</td>
<td>3</td>
<td>PRT</td>
<td>5 Ex. Weeks 1–8, 60–80% 1RM; Weeks 10-14, 70–80%; Week 9 and 15 decrease of 10%</td>
</tr>
<tr>
<td>Dunstan et al. (2002)</td>
<td>36 (19E + 17C)</td>
<td>26</td>
<td>3</td>
<td>PRT+WL vs. WL</td>
<td>9 Ex. Weeks 1–2, 50–60% 1RM; Weeks 3–26, 75–80% 1RM, 8–10 reps</td>
</tr>
<tr>
<td>Cuff et al. (2003)</td>
<td>28 (9C + 10AT + 9ART)</td>
<td>16</td>
<td>3</td>
<td>AT + RT vs. AT</td>
<td>5 RT Ex. intensity not reported, 2 9 12 AT many different modes at 65% HRR</td>
</tr>
<tr>
<td>Dela et al. (2003)</td>
<td>24 (10C + 14E)</td>
<td>12</td>
<td>5</td>
<td>AT</td>
<td>Cycle ergometer at 75% VO₂max</td>
</tr>
<tr>
<td>Balducci et al. (2004)</td>
<td>120 (62E + 58C)</td>
<td>52</td>
<td>2</td>
<td>AT + RT</td>
<td>6 RT Ex. 40–60% 1RM 3 9 12; AT 40–80% HRR</td>
</tr>
<tr>
<td>Tokmakidis et al. (2003)</td>
<td>9</td>
<td>16</td>
<td>2</td>
<td>AT</td>
<td>6 RT Ex. 60% 1RM 3 9 10–15; AT walking / jogging at 65–75% HR max</td>
</tr>
<tr>
<td>Bjoergaas et al. (2005)</td>
<td>29 (15E + 14C)</td>
<td>12</td>
<td>2</td>
<td>PRT+WL vs. WL</td>
<td>Weeks 1–26 PRT (see Dunstan et al., 2002). Weeks 27-52, r.a. supervised / home-based</td>
</tr>
<tr>
<td>Ibanez et al. (2005)</td>
<td>9</td>
<td>16</td>
<td>2</td>
<td>PRT</td>
<td>7–8 Ex. Weeks 1–8, 50–70% 1RM 3 9 10–15; Weeks 9–16, 70–80% 1RM 3–5 9 80% 1RM</td>
</tr>
<tr>
<td>O’Donovan et al. (2005)</td>
<td>36 (13C + 10MI + 13HI)</td>
<td>24</td>
<td>3</td>
<td>AT (HI vs. MI)</td>
<td>Cycle ergometer at 60 or 80% of VO₂max</td>
</tr>
<tr>
<td>Coker et al. (2006)</td>
<td>21</td>
<td>12</td>
<td>4</td>
<td>AT (HI vs. LI)</td>
<td>Cycle ergometer at 50 or 75% of VO₂max</td>
</tr>
<tr>
<td>Dunstan et al. (2006)</td>
<td>57</td>
<td>60</td>
<td>2</td>
<td>PRT+WL vs. WL</td>
<td>Weeks 1–8 PRT (See Dunstan et al., 2002). Weeks 9–60, r.a. centre/home-based</td>
</tr>
<tr>
<td>Sigal et al. (2007)</td>
<td>251 (64C + 60AT + 64RT + 63ART)</td>
<td>22</td>
<td>3</td>
<td>AT vs. RT vs. ART</td>
<td>AT (treadmill or bicycle) at 60–75% of HR max, RT (7 strength machines—2/3 sets at 80% 1RM)</td>
</tr>
<tr>
<td>Church et al. (2010)</td>
<td>262 (41C + 73RT + 72AT + 76 ART)</td>
<td>36</td>
<td>2–3</td>
<td>AT vs. RT vs. ART</td>
<td>AT, ~12 kcal·kg·wk⁻¹, RT, 3·d·wk⁻¹, ART, ~10 kcal·kg·wk⁻¹ + 3·d·wk⁻¹</td>
</tr>
<tr>
<td>Balducci et al. (2010)</td>
<td>606 (303E + 303C)</td>
<td>52</td>
<td>2</td>
<td>Progressive ART</td>
<td>150 min·week⁻¹ over 2 supervised sessions. VO₂max based AT. 4 RT Ex. 3 stretching Ex.</td>
</tr>
<tr>
<td>Kadoglou et al. (2010)</td>
<td>100 (25C + 25AD + 25AT + 25AD, ART)</td>
<td>52</td>
<td>4</td>
<td>AT vs. AD vs. AD + AT</td>
<td>30–45 min AT 50–80% VO₂peak, Weeks 1–28. Weeks 29–52, self-controlled lifestyle programme of 150 min·week⁻¹ AT</td>
</tr>
</tbody>
</table>

KEY: AD, anti-diabetic drugs; ART, combined aerobic and resistance training; AT, aerobic training; C, control group; E, exercise group; Ex., exercises; HI, high intensity; HR max, maximal heart rate; HRR, heart rate reserve; MI, moderate intensity; PRT, progressive resistance training; r.a., randomised to; RM, repetition maximum; RT, resistance training; S, session·week⁻¹; TM, training modality; VO₂peak, peak oxygen uptake; W, duration of programme in weeks; WL, weight loss.
<table>
<thead>
<tr>
<th>Author</th>
<th>Main results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Castaneda et al. (2002)</td>
<td>Decrease in HbA₁c and in prescribed diabetes medications. Increase in muscle glycogen stores</td>
</tr>
<tr>
<td>Dunstan et al. (2002)</td>
<td>Decrease in HbA₁c body weight and fat mass. Increase in lean body mass. No changes in fasting glucose, insulin, serum lipoproteins and resting BP</td>
</tr>
<tr>
<td>Cuff et al. (2003)</td>
<td>ART determined greater increase in glucose infusion rate and muscle density than AT only group. Both groups decreased subcutaneous and visceral fat</td>
</tr>
<tr>
<td>Dela et al. (2003)</td>
<td>Exercise improved β-cell function in moderate, but not low secretors</td>
</tr>
<tr>
<td>Balducci et al. (2004)</td>
<td>12 months of low intensity ART determined a decreased in fasting blood glucose and HbA₁c.</td>
</tr>
<tr>
<td>Tokmakidis et al. (2004)</td>
<td>At 2-h OGTT: reductions of glucose and insulin areas under the curve. Improvement of muscular strength and aerobic capacity. No changes in BMI</td>
</tr>
<tr>
<td>Bjørngaas et al. (2005)</td>
<td>Increase in pedometer activity correlated with fall in HbA₁c, blood pressure, and increase in VO₂max</td>
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<tr>
<td>Dunstan et al. (2005)</td>
<td>Reduced adherence and exercise training volume and intensity limit the effectiveness of home-based, non-supervised training for maintaining improved glycaemic control</td>
</tr>
<tr>
<td>Ibanez et al. (2005)</td>
<td>PRT determined increase of legs and arm strength and increase of insulin sensitivity. Fasting blood glucose, visceral and subcutaneous fat decreased</td>
</tr>
<tr>
<td>O’Donovan et al. (2005)</td>
<td>Moderate-intensity exercise is as effective as high-intensity exercise when 400 kcal expended per session in: insulin sensitivity score and insulin concentration</td>
</tr>
<tr>
<td>Coker et al. (2006)</td>
<td>Insulin stimulated glucose disposal did not changed with moderate-intensity exercise training while it increased by 20% with high-intensity exercise</td>
</tr>
<tr>
<td>Dunstan et al. (2006)</td>
<td>Centre-based but not home-based RT associated with maintenance of modestly improved glycaemic control, associated with programme adherence.</td>
</tr>
<tr>
<td>Sigal et al. (2007)</td>
<td>Either AT or RT alone improve glycaemic control in T2DM, but the improvements are greater with ART</td>
</tr>
<tr>
<td>Church et al. (2010)</td>
<td>ART compared with the non-exercise control, AT or RT alone is needed to improve HbA₁c levels</td>
</tr>
<tr>
<td>Balducci et al. (2010)</td>
<td>Counselling alone, can lead to achieving the currently recommended physical activity guidelines, but of limited efficacy on cardiovascular risk factors, suggesting support and larger volume of exercise required</td>
</tr>
<tr>
<td>Kadoglou et al. (2010)</td>
<td>The addition of exercise to rosiglitazone treatment counteracts drug-related negative effects on body mass, LDL, and TC</td>
</tr>
</tbody>
</table>

**KEY:** ART, combined aerobic and resistance training; AT, aerobic training; BMI, body mass index; HbA₁c, glycosylated haemoglobin; LDL, low-density lipoprotein; OGTT, oral glucose tolerance test; RT, resistance training; T2DM, type 2 diabetes mellitus; TC, total cholesterol; VO₂max, maximal oxygen consumption.
Exercise, both aerobic and resistance training have been shown to produce beneficial effects by reducing HbA$_{1c}$, improving body composition, lipid profile and blood pressure in patients with T2DM. Combined aerobic and resistance training has more recently been found to be more effective than either one alone in ameliorating HbA$_{1c}$. Notable combined aerobic and resistance exercise studies include the DARE (Sigal et al., 2007), Church et al. (2010) and IDES (Balducci et al., 2010) studies.

Sigal et al. (2007) were among the first to report that combined training may be of greater benefit for glycaemic control than either aerobic or resistance exercise alone in patients with T2DM. However, the additional benefit observed might have been due to the extra exercise time in the combination group (approximately double that in the single-exercise groups). Church et al. (2010) sought to address this uncertainty by comparing aerobic training, resistance training and a combination of both on glycaemic control in adults with T2DM. In the Church et al. trial, the authors suggested the duration of weekly training was similar across the three intervention groups equating to approximately 150 min·week$^{-1}$ of activity. The main finding of the Church and colleagues study was that significantly improved glycaemic control was observed only in the combination group, supporting the guideline recommendation that optimal physical activity programs consist of regular aerobic activity combined with resistance training. The IDES (Balducci et al., 2010), a multicentre randomized controlled trial, was of larger size and longer duration than any previously published trials. It was designed to assess the combined effect of structured counselling and supervised mixed (aerobic plus resistance) exercise training, as compared with counselling alone, on HbA$_{1c}$ and other cardiovascular risk factors as well as fitness parameters in individuals with T2DM. In IDES, the intervention group increased physical activity more than the control group even after exclusion of the supervised portion of the exercise, despite both groups receiving identical counselling aimed at increasing physical activity. This finding is in contrast to what was found in the DARE trial (Sigal et al., 2007) in which background physical activity outside of scheduled facility-based training sessions did not change in any group. An important outcome of the IDES study are the superior results achieved in the intervention group even though during the trial clinicians made ongoing efforts to achieve clinical targets in both groups, with no constraints on medication changes. While it could be argued
the differences in medication adjustments may make the IDES study less definitive than the DARE trial, these differences emphasise the real-world applicability of the IDES results.

To date, the IDES trial in particular has demonstrated the effectiveness, feasibility, and sustainability of a supported exercise programme at a population level. Building on the findings of previous studies it also demonstrated the key additional contribution of a supervised, facility-based exercise programme vs. simply counselling patients to exercise. The IDES study supports the addition of supervised, facility based exercise training to standard therapy for T2DM, just as exercise-based cardiac rehabilitation is considered part of the optimal treatment of patients with acute cardiac events. Further research is needed to establish the volume, intensity and type of exercise that are required to reduce cardiovascular burden particularly among newly diagnosed patients, and to define the best strategy for promoting long-term compliance in individuals with T2DM.

2.4.5 Meta-analyses and reviews of exercise interventions

Meta-analyses have been particularly useful in summarising and analysing prior research as well as accounting for often small samples sizes and limited statistical power characteristic of many individual studies in the area. Boulé et al. (2001) undertook a systematic review and meta-analysis investigating the effects of structured exercise interventions in clinical trials of duration ≥8 weeks on HbA1c and body mass in people with T2DM. Twelve aerobic training studies and two resistance training studies were included (totalling 504 participants). The exercise and control groups did not differ at baseline in HbA1c or body mass. Post-intervention HbA1c was significantly lower in exercise than control groups (7.65 vs. 8.31%, weighted mean difference -0.66%; P<0.001). In contrast, post-intervention body mass did not differ between exercise and control groups suggesting the beneficial effect of exercise on HbA1c was independent of any effect on body mass, but was instead associated with improved cardiorespiratory fitness as indicated by statistically significant effect on VO2max. While the significant effect of exercise on HbA1c in these studies is encouraging, the lack of overall effect of exercise on body mass in these studies is not surprising. The average exercise volume (53 min·session⁻¹, 3 sessions·week⁻¹, for a
duration of 15 weeks) may have been insufficient to achieve the energy deficit necessary for major weight loss.

A subsequent meta-analysis addressing exercise intensity and T2DM was performed (Boulé et al., 2003). The inclusion criteria required controlled clinical trials (≥8 weeks duration) evaluating aerobic exercise intervention with detailed prescription and supervised intervention. Seven studies were selected, with nine comparisons and a total of 266 participants. The average exercise volume in this instance was 49 min·session⁻¹, 3 sessions·week⁻¹, for an average of 20 weeks at an average intensity of 55% \( \text{VO}_{2\text{max}} \). The authors concluded exercise intensity was a better predictor than exercise volume for the difference in \( \text{HbA}_1\text{c} \) and \( \text{VO}_{2\text{max}} \) between the exercise and the control group. Among the studies included in this meta-analysis, Mourier et al. (1997) reported the findings from twenty-one participants (exercise, n=10; controls, n=11) who underwent cycle ergometry training 3 sessions·week⁻¹ at 75% of \( \text{VO}_{2\text{peak}} \) for 2 weeks. Subsequently, exercise participants trained for 8 weeks on a cycle ergometer combining training at 75% of \( \text{VO}_{2\text{peak}} \) (continuous for 45 min) and interval training (5 cycles for 2 min) at 85% of \( \text{VO}_{2\text{peak}} \) alternating with 3 min at 50% of \( \text{VO}_{2\text{peak}} \). An additional week of training was added if a day of training was missed (this occurred for two men). Of the studies included in Boulé et al. (2003) meta-analysis, Mourier et al. (1997) saw the greatest effect of exercise on \( \text{HbA}_1\text{c} \) (average post-intervention difference of 1.5% between exercise and control groups) as well as the highest exercise intensity. The results, based on the 10 completers showed \( \text{VO}_{2\text{max}} \) increased 41% in the exercising participants vs. 1% in control participants. In the exercising group abdominal visceral fat assessed by magnetic resonance imaging was reported to decline by 48% and abdominal subcutaneous fat by 18%. Such declines in visceral and subcutaneous fat are much larger than those seen in most exercise studies and surprising in light of the relatively moderate total energy expenditure on exercise suggesting intensities of 75 and 85% contributed.

Boulé et al. (2003) meta-analysis provides support for higher-intensity aerobic exercise in people with T2DM as a means of improving \( \text{HbA}_1\text{c} \). The analysis, however, is limited by the fact that only one study (Mourier et al., 1997) featured an unequivocally high-intensity exercise programme at 75% of \( \text{VO}_{2\text{max}} \). This intensity might be difficult to sustain or even hazardous for many previously sedentary people.
with T2DM (Sigal et al., 2004). Nevertheless, there was a strong dose-response relationship between exercise intensity across the studies investigated with both cardiorespiratory fitness and HbA\textsubscript{1c} levels improving.

Earlier meta-analyses focused largely on aerobic exercise interventions reflecting the dominance of that modality, however more recent meta-analyses (Snowling and Hopkins, 2006; Thomas et al., 2006) have been conducted to investigate the effects of different exercise modes among individuals with T2DM. A meta-analysis conducted by Snowling and Hopkins (2006) sought to investigate the effects of different modes of exercise training on measures of glucose control and other risk factors for complications of diabetes. 27 studies controlled trials providing, for each measure, 18 estimates for the effect of aerobic training, 7 for resistance training, and 5 for combined training, with 1,003 type 2 diabetic patients (mean age 55 [7] years) over 5-104 weeks were included. Differences among the effects of aerobic, resistance, and combined training on HbA\textsubscript{1c} were non-significant statistically; for training lasting ≤12 weeks, the overall effect was a small beneficial reduction (0.8% [0.3]). There were generally small to moderate benefits for other measures of glucose control. For other risk factors, there were either small benefits or effects were insignificant or unclear, although combined training was generally superior to aerobic and resistance training alone. Thomas et al. (2006) meta-analysis included randomized controlled trials comparing any type of well-documented aerobic, fitness or progressive resistance training exercise with no exercise in people with T2DM. The authors independently selected trials, assessed trial quality and extracted data including any information on adverse effects from the trials. Fourteen randomized controlled trials comparing exercise against no exercise in T2DM involving 377 participants were included. Trials ranged from eight weeks to twelve months duration. Compared with the control, the exercise intervention significantly improved glycaemic control as indicated by a decrease in HbA\textsubscript{1c} levels of 0.6% (-0.6% HbA\textsubscript{1c}, 95% confidence interval (CI) -0.9 to -0.3; P < 0.05). There was no significant difference between groups in whole body mass, possibly due to an increase in fat free mass (muscle) with exercise, as reported in one trial (6.3 kg, 95% CI 0.0 to 12.6). Following exercise visceral adipose tissue and subcutaneous adipose tissue also decreased significantly. Overall the exercise interventions significantly increased insulin response and decreased plasma triglycerides. No significant difference was found between groups in plasma
cholesterol or blood pressure. No study reported adverse effects in the exercise group or diabetic complications.

The impact of exercise on lipid profiles among individuals with T2DM has also been investigated. Kelley and Kelley (2007) conducted a meta-analysis of randomized-controlled trials in order to examine the effects of 8 weeks or more of aerobic exercise on lipids and lipoproteins. Studies were included if TC, HDL-C, LDL-C, ratio of TC to HDL-C (TC/HDL-C), TG, or all of the above, were assessed. A secondary outcome was HbA1c. Seven studies representing 220 men and women (112 exercise, 108 control) were available for analysis. Using a random-effects model, a statistically significant reduction of about 5% was found for LDL-C, whereas no statistically significant improvements were found for TC, HDLC, TC/HDL-C or TG. A trend for a statistically significant reduction in HbA1c was also found. The results suggest that aerobic exercise lowers LDL-C in those with T2DM however the more research focused on the impact of both aerobic and resistance activity on lipid profiles among this population are required.

Lastly, a recent meta-analysis by Chudyk and Petrella (2011) investigated the effects of exercise mode on cardiovascular risk factors. Of the 34 studies included in the analysis, 21 investigated aerobic exercise alone, 8 studies investigated resistance exercise alone and 10 reported combined exercise training. Among the aerobic exercise studies, exercise sessions ranged from 1-7 sessions·week\(^{-1}\), with 13 of the 21 studies prescribing 3 sessions·week\(^{-1}\). Exercise intensity ranged between 50 and 85% \(\text{VO}_2\text{max}\) or \(\text{VO}_2\text{peak}\) and 55 and 85% \(\text{HR}_{\text{max}}\). Duration of exercise sessions ranged between 40 – 75 min and the duration of interventions ranged from 8 – 52 weeks. For resistance exercise interventions there was an average of three supervised exercise sessions·week\(^{-1}\), while exercise duration ranged between 8 – 26 weeks. Exercise intensity ranged between 50 and 80% 1 repetition maximum among the studies. Of the 10 studies which utilized combined aerobic and resistance exercise six of the studies involved supervised exercise carried out three sessions·week\(^{-1}\), two studies involved bi-weekly sessions, one study involved four sessions·week\(^{-1}\) sessions, and one study involved a goal of participants engaging in exercise 5 days·week\(^{-1}\). Intensity of the prescribed aerobic exercise varied between an initial exercise intensity of 35% \(\text{HR}_{\text{max}}\) to an upward maximum of 85% \(\text{HR}_{\text{max}}\). The resistance component of the
interventions varied in terms of prescribed load, repetition, and number of sets. Duration of the interventions ranged between 8 – 104 weeks months, with nine of the ten studies lasting at least 12 weeks. Aerobic alone or combined with resistance training significantly improved HbA_1c_-0.6 and -0.67%, respectively (95% CI -0.98 to -0.27 and -0.93 to -0.40, respectively), systolic blood pressure (SBP) -6.08 and -3.59 mmHg, respectively (95% CI -10.79 to -1.36 and -6.93 to -0.24, respectively), and triglycerides -0.3 mmol·L⁻¹ (95% CI -0.48 to -0.11 and -0.57 to -0.02, respectively). Waist circumference was significantly improved -3.1 cm (95% CI -10.3 to -1.2) with combined aerobic and resistance exercise, although fewer studies and more heterogeneity of the responses were observed in the latter two markers. Resistance exercise alone or combined with any other form of exercise was not found to have any significant effect on cardiovascular markers. The authors concluded that aerobic exercise alone or combined with resistance training improves glycaemic control, SBP, triglycerides, and waist circumference. While the impact of resistance exercise alone on cardiovascular risk markers in T2DM remains unclear.

The studies reviewed in section 2.4 were included as they had a no-exercise or standard care control group; exercise intervention could be quantified in terms of frequency, intensity, duration, and time; and the studies investigated the chronic effects of exercise as opposed to acute among patients with T2DM. Supervised exercise and in particular combined aerobic and resistance exercise activity has been shown to provide numerous benefits to those with T2DM. Larger scale studies such as those undertaken by Sigal et al. (2007), Church et al. (2010), and Balducci et al. (2010) in combination with meta-analyses and reviews demonstrate that supervised exercise training and its range of clinically beneficial effects should be offered as an evidence-based therapy and supported in the same way as nutritional therapy and medications. However, as with other vital components of diabetes care such as the prescription of medication, recommended dietary regimens, and smoking cessation advice and support; participant non-compliance is a major obstacle to successful diabetes management outcomes. Similarly to how these aspects of diabetes management can be affected by patient non-compliance, many patients may decline to participate in exercise however a lack of compliance alone should not be regarded as a sufficient reason to withhold this important therapy.
2.4.6 Individual differences in response to exercise
Most studies evaluating the efficacy of exercise tend to report the mean data often overlooking the inter-individual variability (King et al., 2008). While it is unlikely that a fixed dose of exercise will be effective to the same extent in all individuals, a failure of exercise to elicit significant changes in a given phenotype is often assumed to demonstrate a lack of effectiveness of the exercise treatment. However, if a comparison is made between responses to exercise and drug treatment within a clinical setting - where the phenomenon of variability in response is well established (Wilkinson, 2005) – interventions may only be effective in 25–60% of patients. Bouchard and Rankinen (2001), suggests when all members of an exercising group are exposed to the same volume and intensity of exercise adjusted for their own tolerance level the effectiveness of exercise on a given phenotype may still vary. For example, the impact of exercise on weight loss has variable success because some individuals recruit adaptive mechanisms to oppose the negative energy balance resulting from the imposed exercise (Stubbs et al., 2004).

Bouchard (1983) produced the first publication addressing individual differences in response to standardised exercise programmes. Bouchard (1983) suggested reporting of the mean response to an exercise regimen can be very misleading. For instance, a mean increase in endurance performance of 25% hides the fact that some individuals may have experienced a much lower gain or no increase at all in endurance, whereas some others may have gained as much as 50% or more. For example in the Heritage study, a range of 0-100% increase in VO$_{2\text{max}}$ was observed among sedentary participants undergoing a progressive aerobic exercise training programme of three sessions·week$^{-1}$ at a final heart rate that was 75% of their initial VO$_{2\text{max}}$ for 50 min·day$^{-1}$ for 15–20 weeks (Bouchard et al., 1999). Other studies have shown a similar heterogeneity in VO$_{2\text{max}}$ (mean increase 24%; range 0-58%) adaptation to similar exercise interventions (Kohrt et al., 1991). Adaptations to training such as reduced heart rate at low work loads, improvements in blood pressure and improvements in insulin sensitivity in diabetic patients all have variable magnitudes in responses to exercise training among participants in the same study (Bouchard and Rankinen, 2001; Fritz et al., 2006). Interestingly, genetics have been calculated to contribute 48% of the variable response in VO$_{2\text{max}}$ (Bouchard et al., 1999), implying non-genetic causes for the other 52% of the variation.
Studies investigating the heterogeneous response to exercise in a group of participants often focus on a specific phenotype and employ the term ‘non-responder’. Booth and Laye (2010) suggest the generalised term ‘non-responder’ is misleading as it implies that no exercise-induced adaptations occur. Alternatively, Booth and Laye (2010) suggest there is simply variation in responses to the same stimuli, and a more appropriate terminology would be ‘high sensitivity’ and ‘low sensitivity’. Given that response to exercise is polygenic within a given organ and affects multiple organ systems, there are likely other undetermined adaptations that do respond to exercise (Booth and Laye, 2010). For example, Vollaard et al. (2009) demonstrated that participants who did not increase VO$_{2\text{max}}$ in response to aerobic exercise did show improvements in oxidative enzyme activities in muscle. Importantly, while VO$_{2\text{max}}$ was correlated with performance both before and after the training intervention, the percentage change in VO$_{2\text{max}}$ with training was not associated with the participants change in physical performance. This suggests improved performance must have occurred through alternative adaptations in those who express low sensitivity to increasing VO$_{2\text{max}}$ in response to endurance-type training. Thus, failure to improve one specific phenotype or observable trait at group or individual level is not reason enough to cease or fail to recommend or prescribe exercise in the prevention and treatment of chronic disease (Kraushaar and Krämer, 2009).

2.5 Physical activity advice and type 2 diabetes mellitus

In contrast to structured exercise training, physical activity is defined as any bodily movement produced by skeletal muscle contractions resulting in increased energy expenditure (Sigal et al., 2004). Although structured exercise training such as that described in Section 2.4, has benefits for individuals with T2DM, the nature of such programmes often mean they are only available to subsets of patients. This, in part is reflected by the small sample sizes of many of the reviewed studies with the exception of Sigal et al. (2007), Church et al. (2010) and Balducci et al. (2010). Provision of physical activity advice however is more feasible and could be offered to most patients with T2DM. However, relatively few studies have been undertaken to determine whether physical activity advice is associated with the same benefits structured exercise provides such as, increased activity levels, and improved physiological status such as reduced HbA$_{1\text{c}}$ levels. The following section focuses on
interventions investigating the effects of physical activity advice among patients with T2DM.

Agurs-Collins et al. (1997) randomized 64 T2DM patients aged 55-79 years to either an intervention (12 weekly group sessions, 1 individual session, and 6 biweekly group sessions) or usual care (1 class and 2 informational mailings). Clinical and behavioural variables were assessed at 0, 3, and 6 months of treatment. Significant net differences in the intervention vs. usual care were observed for body mass (-2.0 kg, P=0.006), physical activity, and dietary intake of fat, saturated fat, cholesterol, and nutrition knowledge at 3 months (all P<0.05) and for body mass at 6 months (-2.4 kg; P=0.006) and mean HbA1c values at 3 and 6 months (respectively, -1.6 and -2.4%, both P<0.01). Blood lipid profiles improved more in intervention than usual care participants, but not significantly. While the intervention was effective in improving glycaemic control it is possible the decrease in HbA1c was independent of the relatively modest changes in dietary intake, body mass, and activity and may reflect indirect programme effects on other aspects of self-care such as medication adherence.

DiLoreto et al. (2003) sought to validate a counselling strategy that could be used by physicians in their daily outpatient practice to promote the adoption and maintenance of physical activity by T2DM patients. The long-term (2-year) efficacy of the behavioural approach (n=182) was compared with usual care treatment (n=158) in two matched, randomized groups of patients with T2DM who had been referred to an Outpatient Diabetes Centre. The goal of the intervention was consistent patient achievement of an energy expenditure of >10 METs·h·week\(^{-1}\) through voluntary physical activity. At 2 years, 69% of the patients in the intervention group reported achieving 27.1 [2.0] METs·h·week\(^{-1}\) and 18% of the control group reported 4.1 [0.8] METs·h·week\(^{-1}\). Upon comparison of the two groups, significant (P<0.001) improvements in BMI (intervention group 28.9 [0.2] vs. control group 30.4 [0.3] kg·m\(^{-2}\)) and HbA1c (intervention group 7.0 [0.1] vs. control group 7.6 [0.1] %) were observed. The authors suggested the randomized, controlled study demonstrated that physicians could motivate most patients with T2DM to perform physical activity long-term, emphasising the value of individual behavioural approaches in daily practice. However, the study did not report the frequency of contact between
physicians and patients. It is therefore difficult to interpret the volume of contact time between the physician and patient, thus undermining the generalisability of this approach.

Kirk et al. (2004) investigated the effectiveness of physical activity counselling in promoting physical activity in people with T2DM evaluating resultant physiological and biochemical effects. Physical activity counselling, was based on the Transtheoretical Model, combining motivational theory and cognitive behavioural strategies into an individualized intervention. The researchers randomized a total of 70 individuals with T2DM to receive either standard exercise information via a leaflet (n=35, control group) or standard leaflet plus physical activity counselling (n=35, experimental group). The information leaflet, approved by Diabetes UK, was entitled ‘Exercise and your Diabetes’, and focused on: why a person with diabetes should exercise; recommended amounts of exercise; how to get started; and, how exercise can affect diabetes. Physical activity consultations were delivered at baseline and after 6 months. The consultations aimed to encourage patients to accumulate 30 minutes of moderate physical activity on most days of the week. If participants were already undertaking this level of activity, they were encouraged to progress towards three 20-min sessions of continuous, moderate to hard exercise each week. At baseline, consultation focused on current physical activity level, discussing the benefits, barriers and costs of becoming more active, finding suitable activities, providing social support, setting goals, and preventing relapse to sedentary behaviour. Participants at baseline were in either the contemplation or the preparation stage. For those in the contemplation stage, more emphasis was placed on increasing motivation to become more active while for individuals in the preparation stage, emphasis was placed on developing a suitable physical activity plan. Consultations given after 6 months focused preventing relapse to sedentary behaviour and on improving long-term maintenance of a physically active lifestyle. Follow-up phone calls were made at 1, 3, 6 and 9 months. To maintain equal contact time between groups, control participants also received a phone call. However, for the control group phone calls involved discussions unrelated to exercise.

Kirk et al. (2004) assessed changes from baseline after 6 and 12 months for physical activity (7-day recall and accelerometer), physiological characteristics (BMI and
blood pressure) and for biochemical variables (HbA1c, lipid profile, fibrinogen, tissue plasminogen activator and microalbuminuria). Significant differences between groups were recorded for physical activity after 6 and 12 months (P<0.01). The experimental group had increased levels of physical activity from baseline to 6 months (P<0.01), with no decrease from 6 to 12 months (P>0.05). In the control group, accelerometer counts per week decreased from baseline to 12 months (P=0.03). Between-group differences (P<0.05) were recorded for the change in HbA1c (experimental: 0.26% decrease; control: 0.15% increase), for systolic blood pressure (experimental: 7.7 mmHg decrease; control: 5.6 mmHg increase) and for fibrinogen (experimental: 0.28 mmol·l$^{-1}$ decrease; control: 1.43 mmol·l$^{-1}$ increase) from baseline to 6 months, and for TC (experimental: 0.33 mmol·l$^{-1}$ decrease; control: 0.04 mmol·l$^{-1}$ increase) from baseline to 12 months (P<0.05). No significant differences were recorded in other measured variables. The authors argued physical activity counselling was effective in promoting physical activity in people with T2DM. The counselling improved glycaemic control as well as the status of cardiovascular risk factors in these patients. The relatively minimal counselling (at baseline and 6 months only) and follow-up telephone calls suggests the overall intervention could be undertaken among a wider population. The success behind the intervention may be due to the individualised, theory-based approach to counselling, however, further research would be required to confirm this.

Tudor-Locke et al. (2004) conducted a randomized trial, the First Step Programme (FSP) for adults with T2DM. The trial consisted of a 16-week intervention study and 24-week follow-up assessment. 47 overweight/obese, sedentary individuals (age=52.7 [5.2] years; BMI=33.3 [5.6] kg·m$^{-2}$) were recruited through a diabetes education centre. The FSP required participants to attend an adoption phase (initial 4 weeks), involving four weekly group meetings (individual attendance was recorded). During this period participants were given pedometers and a programme manual containing goal setting and problem-solving exercises, as well as calendars for self-monitoring steps·day$^{-1}$. No specific advice was given concerning diet or glycaemic control. During the subsequent 12 weeks, participants were asked to use their pedometers and calendars for goal-setting and self-monitoring. Pedometers and calendars were returned at the 16-week assessment. Calendars were examined to verify pedometer use, the number of days·week$^{-1}$ personal goals were achieved (for each of the first 4
weeks), and to calculate the mean steps·day\(^{-1}\). The primary measure, daily physical activity levels was assessed by pedometer (steps·day\(^{-1}\)). Other measured parameters included: anthropometric measures (body mass, BMI, waist and hip circumference); indicators of cardiovascular health (resting heart rate and blood pressure); glycaemic control (FPG, insulin, HbA\(_{1c}\), glucose concentration 120 min post-glucose load); plasma lipid status (TC, HDL-C, LDL-C, and TG). In comparison to the control group, FSP participants increased their physical activity >3000 steps·day\(^{-1}\) (approximately 30 min·day\(^{-1}\)) during the intervention (P<0.0001). FSP participants waist and hip girth decreased (approximately 2-3 cm), but did not differ significantly between to controls. Significant changes did not emerge for any of the other variables. The authors suggested the FSP represented a practical intervention for immediately changing walking behaviour i.e. increasing the volume and/or intensity of physical activity necessary to improve long-term health outcomes among individuals with T2DM. However, the authors also acknowledged an apparent relapse among participants of the FSP by 24 weeks indicating that other strategies to provide continual support were necessary to maintain lifestyle change. Notably, the FSP intervention did not include other forms of physical activity as the authors suggested other types of activity were relatively uncommon among individuals with T2DM and quantification of other activities could prove problematic. The lack of choice and variety in terms of physical activities may be an important aspect of the relapse observed in the Tudor-Locke et al. (2004) study.

Jackicic et al. (2009) examined the effect of an intensive lifestyle weight loss intervention (ILI) compared to diabetes support and education (DSE) on changes in fitness and physical activity in the Look AHEAD trial. In this randomized clinical trial data from 4376 overweight or obese adults with T2DM (age=58.7 [6.8] years, body mass index (BMI=35.8 [5.8] kg·m\(^{-2}\)) who completed 1 year of the Look AHEAD trial and had available fitness data were analyzed. Participants were randomly assigned to DSE or ILI. DSE received standard care plus three education sessions over the 1-year period. ILI included individual and group contact throughout the year, restriction in energy intake and 175 min·week\(^{-1}\) of prescribed physical activity. Following adjustment for baseline fitness, change in fitness was statistically greater in ILI vs. DSE after adjustment for baseline fitness (20.9 vs. 5.7%, P<0.0001). Multivariate analysis showed that change in fitness was greater in overweight (BMI >
25.0 kg·m$^{-2}$) vs. obese (BMI > 30.0 kg·m$^{-2}$) (P<0.05). Physical activity increased by 892 [1694] kcal·week$^{-1}$ in ILI vs. 108 [1254] kcal·week$^{-1}$ in DSE (P<0.01). Changes in fitness (r=0.41) and physical activity (r=0.42) were significantly correlated with reduction in body mass (P<0.0001). The authors concluded the ILI was effective in increasing physical activity and improving cardiorespiratory fitness in overweight and obese individuals with T2DM.

Kirk et al. (2009) argue that despite physical activity being recognised as a cornerstone of T2DM management it remains underutilized. The authors suggested physical activity consultations can increase physical activity in people with T2DM but resources are often limited. Kirk et al. (2009) designed Time2Act, a randomized control trial to study the 12-month effectiveness of a physical activity consultation delivered by a person or in written form, in contrast to standard care, for people with T2DM. A total of 134 inactive individuals with T2DM in a contemplation or preparation stage (as indicated by the Transtheoretical Model) were randomized to either intervention or standard care. Objective (accelerometer) and subjective (7-day recall) physical activity levels were measured over 1 week, along with physiological (blood pressure, BMI, waist circumference) and biochemical (HbA$_{1c}$, Total and HDL-C) measures at baseline, 6 and 12 months. In contrast to the authors previous findings (Kirk et al., 2004) in the present study neither a physical activity consultation delivered by a person nor in written form was better than standard care at increasing physical activity levels or improving health outcomes in the full study cohort. Total and HDL-C, waist circumference and both systolic and diastolic blood pressure improved over 12 months in all groups, whilst HbA$_{1c}$ improved over 6 months. In a subgroup (baseline pedometer steps < 5000·day$^{-1}$), the physical activity consultation delivered by a person significantly increased physical activity over 12 months while the standard care group significantly decreased activity levels, suggesting individual consultation may be of benefit among individuals at achieving equivalent levels of activity. Kirk et al. (2009) suggest more research is needed which not only investigates the most economical and effective methods to promote physical activity, but also the best setting to conduct physical activity consultations and the participant factors affecting uptake of physical activity in T2DM.
Diedrich et al. (2010) aimed to evaluate the effectiveness of a self-help physical activity programme for 53 individuals with T2DM. Effectiveness was measured by cardiovascular indicators, HbA$_{1c}$, anthropometric indicators, and self-reported physical activity levels. Participants were randomly assigned to an intervention group which attended the usual Diabetes Self-Management Education Programme (DSMEP) and received a copy of the book summarising the key points of Manpo-kei, and a pedometer. Manpo-kei, a Japanese term, for a pedometer or step counter simply referred to an approach to increasing physical activity using a pedometer-based programme with individual goal setting and self-monitoring. The approach was the basis of the Tudor-Locke et al. (2004) FSP intervention. Participants assigned to the control group attended the usual DSMEP only. Data collection was completed at the beginning of the study and 3 months later using a lifestyle and diabetes questionnaire, a physical activity questionnaire, and cardiovascular and anthropometric measures. Those who participated in the intervention demonstrated a significant decrease in HbA$_{1c}$, body mass, and body fat. In addition, they increased their number of daily steps as measured by the pedometer. The control group also demonstrated a significant decrease in HbA$_{1c}$ and body mass. Both groups demonstrated increases in their regular weekly activity. The researchers concluded that pedometers can be a helpful strategy to motivate persons with diabetes to increase physical activity. However, similarly to participants in the DSE group of Jackicic et al. (2009) it appears that attendance at DSMEP may be enough to increase physical activity for persons with T2DM.

While most exercise and physical activity advice interventions have included participants with established diabetes, Andrews et al. (2011) performed a randomised, controlled trial among newly diagnosed T2DM patients (diagnosed 5-8 months previously) aged 30-80 years. The Early ACTID (Early ACTivity In Diabetes) trial examined the benefits of dietary intervention versus diet plus physical activity for glycaemic control and other metabolic factors. The 52-week, multicentre trial had three groups: usual care (control group, initial dietary consultation and follow-up every 6 months), diet only (dietary consultation every 3 months with monthly nurse support), and diet plus activity (as diet group, plus advice to achieve more than 30 min brisk walking five times·week$^{-1}$ assessed through the use of pedometers). The 593 eligible patients were assigned to the groups in a ratio of two:five:five (99 usual care,
248 diet only, and 246 diet plus activity). The randomisation ratio was justified as the primary comparison was diet plus activity versus diet only, with only a secondary interest in usual care. At 6 months, glycaemic control had worsened in the control group, but baseline-adjusted difference in percentage HbA$_1c$ was -0.28% (P=0.005) in the diet only intervention group, and -0.33% (P<0.001) in the diet plus activity group. Although the difference between the intervention groups was not significant, the changes remained at 12 months despite less use of diabetes drugs. Compared with controls, patients in both the diet and diet and activity groups had significant improvements in the secondary outcomes of body mass, waist circumference, and insulin resistance at both 6 months and 12 months, and use of hypoglycaemic medication at 12 months. There was no evidence of further benefits from addition of physical activity to dietary intervention.

Andrews et al. (2011) argue that, although more intensive dietary advice improved outcomes compared with usual care, there is no justification to add a physical activity component on top of the dietary programme to manage newly diagnosed T2DM. However, a number of issues should be considered. Despite participants being advised to achieve more than 30 min of brisk walking on at least 5 days·week$^{-1}$ and data from pedometers were suggestive of very good adherence there were no further improvement of outcomes with addition of physical activity to dietary counselling. Previous clinical trials have shown that increased physical activity, including brisk walking, significantly improves glycaemic control among patients with pre-existing diabetes (Snowling and Hopkins, 2006). The Early ACTID trial did not include a group assigned only physical activity; therefore, the results do not necessarily mean that an increase in physical activity is ineffective for diabetes management. It is possible that the trial in avertedly placed greater emphasis on dietary modification even within the diet plus physical activity arm. It should be acknowledged that like Jackicic’s and colleagues intervention, the Early ACTID study directed considerable resources at the dietary component of the intervention which makes direct comparison between outcomes of structured exercise and physical activity advice interventions less conclusive. Additionally, modification of two complex behaviours at the same time may be no more effective than a change in one – for instance, the need for effort in both aspects of life may have diminished positive dietary changes by patients in the diet plus physical activity group (Jones et al., 2003). However, it is notable that
following subgroup analyses, a combination of diet and physical activity worked significantly better than diet only in participants with higher HbA$_{1c}$, insulin resistance, and BMI at baseline, suggesting those at higher risk may benefit most. Summaries of the reviewed physical activity studies are displayed in Tables 2.3 and 2.4.

Review of studies in Table 2.3 suggests translation of findings from physical activity interventions into community settings requires considerable concerted efforts by patients, dieticians, and clinicians. In the Early ACTID study (Andrews et al., 2011), the enhanced dietary programme included 6.5 h of individual counselling throughout the year (2 h with a dietician and 4.5 h with a nurse). In comparison, the Look AHEAD participants in the ILI group met with dieticians, behavioural counsellors, or exercise specialists every week for the first 6 months, and three times·month$^{-1}$ for the next 6 months (Jackicic et al., 2009).

### Table 2.3 Summary of physical activity advice studies

<table>
<thead>
<tr>
<th>Author</th>
<th>Participants</th>
<th>Control</th>
<th>Intervention</th>
<th>W</th>
<th>S</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agurs-Collins et al. (1997)</td>
<td>64 (32PA + 32C)</td>
<td>Usual care, nutrition advice, info. mailing</td>
<td>Individual and group sessions</td>
<td>26</td>
<td>3</td>
<td>90 min</td>
</tr>
<tr>
<td>DiLoreto et al. (2003)</td>
<td>340 (182PA + 158C)</td>
<td>Usual care, diet counselling</td>
<td>Individual physician counselling</td>
<td>104</td>
<td>NR</td>
<td>&gt;10·hr$^{-1}$</td>
</tr>
<tr>
<td>Kirk et al. (2004)</td>
<td>70 (35PA + 35C)</td>
<td>Usual care</td>
<td>Consultation and follow-up phone calls</td>
<td>26</td>
<td>5</td>
<td>150 min</td>
</tr>
<tr>
<td>Tudor-Locke et al. (2004)</td>
<td>47 (24PA + 23C)</td>
<td>Usual care</td>
<td>Physician consultation</td>
<td>16</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Jakicic et al. (2009)</td>
<td>5061 (2486ILI + 2575DSE)</td>
<td>Usual care and diabetes support education</td>
<td>Individual and group contact, diet plan, exercise prescription</td>
<td>52</td>
<td>5</td>
<td>175 min</td>
</tr>
<tr>
<td>Kirk et al. (2009)</td>
<td>28 (51PA + 35C)</td>
<td>Usual care</td>
<td>Oral and written physical activity advice, accelerometer</td>
<td>52</td>
<td>5</td>
<td>150 min</td>
</tr>
<tr>
<td>Andrews et al. (2011)</td>
<td>593 (248ID + 246 IDPA + 99C)</td>
<td>Usual care</td>
<td>Dietary consultation tri-monthly + monthly nurse support. Or above plus pedometer based activity programme</td>
<td>52</td>
<td>5</td>
<td>150 min</td>
</tr>
</tbody>
</table>

KEY: C, control; D, weekly duration; DSE, diabetes support and education; ID, intensive dietary support; ILI, intensive lifestyle weight loss intervention; NR, not reported; PA, physical activity advice; S, session·week$^{-1}$; W, duration of programme in weeks.
### Table 2.4 Summary of physical activity advice studies results

<table>
<thead>
<tr>
<th>Author</th>
<th>Main results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agurs-Collins et al. (1997)</td>
<td>Decrease in HbA\textsubscript{1c}, independent of modest changes in dietary intake, body mass, activity, may reflect indirect effects on other self-care behaviours such as medication adherence</td>
</tr>
<tr>
<td>DiLoreto et al. (2003)</td>
<td>Decrease in BMI and HbA\textsubscript{1c}, through motivation to perform physical activity long-term, emphasising the value of individual behavioural approaches in daily practice</td>
</tr>
<tr>
<td>Kirk et al. (2004)</td>
<td>Physical activity counselling improved glycaemic control as well as the status of cardiovascular risk factors</td>
</tr>
<tr>
<td>Tudor-Locke et al. (2004)</td>
<td>Increasing volume and/or intensity of physical activity necessary to improve long-term health outcomes. Continued support such as booster sessions are needed to maintain lifestyle change</td>
</tr>
<tr>
<td>Jakicic et al. (2009)</td>
<td>Intensive weight loss lifestyle intervention effective in increasing physical activity and improving cardiorespiratory fitness</td>
</tr>
<tr>
<td>Kirk et al. (2009)</td>
<td>Physical activity consultation delivered by a person significantly increased physical activity over 12 months</td>
</tr>
<tr>
<td>Diedrich et al. (2010)</td>
<td>Both control and intervention group’s increased weekly activity decreased HbA\textsubscript{1c} and body mass significantly. Diabetes self-management education programme alone may be enough to increase physical activity</td>
</tr>
<tr>
<td>Andrews et al. (2011)</td>
<td>Intensive diet intervention can improve glycaemic control among newly diagnosed T2DM, additional physical activity advice no further benefit.</td>
</tr>
</tbody>
</table>

KEY: BMI, body mass index; HbA\textsubscript{1c}, glycosylated haemoglobin; T2DM, type 2 diabetes mellitus.

There is little doubt that improved nutrition and physical activity are beneficial for individuals with T2DM. However, it is difficult to draw definitive ‘physical activity’ conclusions from many of the interventions referenced in Tables 2.3 and 2.4 as they often also include advice and counselling focused on dietary modification and fail to include a physical activity alone group. The long-term effects, cost-effectiveness and sustainability of these programmes also need to be assessed in future studies.

### 2.6 Structured exercise training in comparison to physical activity advice

A recent meta-analysis by Umpierre et al. (2011) has demonstrated that structured aerobic, resistance or combined exercise training is associated with a reduction in HbA\textsubscript{1c} of -0.67%. Umpierre et al. (2011) also demonstrated that structured exercise of > 150 minutes·week\textsuperscript{-1} was associated with greater reduction of HbA\textsubscript{1c} (-0.89%) than structured exercise of 150 minutes·week\textsuperscript{-1} or less (-0.39% reduction in HbA\textsubscript{1c}). The meta-analysis performed by Umpierre and colleagues was also the first systematic review to investigate the association between physical activity advice interventions and glycaemic control. Physical activity advice was associated with smaller reductions in HbA\textsubscript{1c} than studies evaluating structured exercise interventions. Umpierre et al. (2011) suggested a recommendation or advice to increase physical activity was beneficial (-0.43% reduction in HbA\textsubscript{1c}) but only if combined with dietary
recommendations. The observations of Umpierre et al. (2011) highlight a number of interesting points surrounding the discussion of structured exercise vs. physical activity advice. Arguably physical activity advice may be as good as exercise intervention of ≤ 150 minutes·week^{-1} in helping patients to reduce HbA_{1c} levels, providing it is supplied in combination with dietary advice. The review suggests benefits can be derived from combined lifestyle recommendations from a clinical practice perspective, but also suggests there is a possibility that the outcomes of previous interventions investigating the effect of structured exercise or physical activity advice may have been weakened by the provision of dietary advice to participants of these studies. The volume of structured exercise undertaken also appears to be very important and exercise/physical activity recommendations of ≤ 150 minutes·week^{-1} may fail to elicit the necessary activity levels to achieve further reductions in HbA_{1c} among individuals with T2DM.

Further to the issues raised by Umpierre et al. (2011) and key to the debate on the appropriateness of structured exercise or physical activity advice is feasibility. Both structured exercise interventions and physical activity advice have limitations. For instance, many exercise studies (Ibanez et al., 2005; Coker et al., 2006; Balducci et al., 2010; Church et al., 2010) fail to disclose information on participant compliance to intervention regimen making it difficult to evaluate the implications of the research in a real-life setting. This is of particular concern as adherence to exercise has proven to be difficult among healthy population and it is likely that for a clinical population such as those with T2DM population who often have a plethora of management behaviours or treatments to contend with, adherence may prove even more difficult. Like many clinical interventions, participants of exercise studies may often represent a highly motivated subset (Hanefeld et al., 1991) non-representative of the T2DM population as a whole. The generalisability of the results from the aforementioned exercise studies to patients who may be less compliant to exercise programmes is uncertain. Compliance is also a concern among physical activity advice interventions. In contrast to exercise interventions which are largely undertaken in a supervised context where participants are keenly observed by researchers, physical activity interventions are often dependant on subjective self-report methods where it is the participants themselves who are responsible for accurate and up-to-date account of their physical activity levels and achievements. While there are pragmatic and
economic reasons for assessing exercise or physical activity adherence by this approach it does increase the potential for reporting biases and inaccuracy. However, objective methods of assessment such as use of pedometers or accelerometers (Kirk et al., 2004, 2009; Jackicic et al., 2009; Diedrich et al., 2010; Andrews et al., 2011) have made physical activity assessment more reliable and robust.

Table 2.5 illustrates further the issues affecting the feasibility of interventions aimed at increased activity levels among patients with T2DM. Only exercise interventions which reported adherence are included in Table 2.5.

<table>
<thead>
<tr>
<th>Structured exercise Author</th>
<th>Participants</th>
<th>Adherence (%)</th>
<th>Duration (wk)</th>
<th>Physical activity advice Author</th>
<th>Participants</th>
<th>Dropout (%)</th>
<th>Duration (wk)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Castaneda et al. (2002)</td>
<td>62</td>
<td>90</td>
<td>16</td>
<td>Agurs-Collins et al. (1997)</td>
<td>64</td>
<td>9</td>
<td>26</td>
</tr>
<tr>
<td>Balducci et al. (2004)</td>
<td>120</td>
<td>90</td>
<td>52</td>
<td>Jakicic et al. (2009)</td>
<td>5061</td>
<td>4</td>
<td>52</td>
</tr>
<tr>
<td>Bjørgaas et al. (2005)</td>
<td>29</td>
<td>77</td>
<td>12</td>
<td>Kirk et al. (2009)</td>
<td>28</td>
<td>9</td>
<td>52</td>
</tr>
<tr>
<td>Sigal et al. (2007)</td>
<td>251</td>
<td>80</td>
<td>22</td>
<td>Diedrich et al. (2010)</td>
<td>53</td>
<td>40</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Andrews et al. (2011)</td>
<td>593</td>
<td>2</td>
<td>52</td>
</tr>
<tr>
<td><strong>Average:</strong></td>
<td><strong>78</strong></td>
<td><strong>88</strong></td>
<td><strong>22</strong></td>
<td></td>
<td><strong>782</strong></td>
<td><strong>12</strong></td>
<td><strong>42.5</strong></td>
</tr>
</tbody>
</table>

The often expensive and time-consuming nature of structured exercise interventions (Sevick et al., 2000) may well limit the feasibility of such programmes across diabetes care. Intervention such as those undertaken by Sigal et al. (2007) and Balducci et al. (2010) demonstrate that large cohorts of patients can be reached by structured supported/supervised exercise programmes. However, it is also worth noting these interventions were multi-centre based involving 8 and 22 centres respectively, further emphasising the large network of support and necessary resources required for this.
approach. Among exercise intervention trials the average number of participants and duration of exercise intervention programmes were 78 participants and 22 weeks, whereas for physical activity advice interventions the average number of study participants was 782 and trial duration 42.5 weeks. Physical activity advice may be more feasible than supported or supervised exercise, but time and support devoted to counselling can prove to be considerable and the long-term efficacy of this approach is not clear. Therefore, the question of how best to promote physical activity among the T2DM population remains.

2.7 Understanding physical activity behaviour in type 2 diabetes mellitus

Despite the wealth of information on the benefits of exercise, many individuals with T2DM do not achieve the recommended level for physical activity (Plotnikoff et al., 2011a). Research investigating low levels of physical activity and sedentary behaviour has focused on avoidance of physical activity, determinants of physical activity, barriers to physical activity, beliefs about physical activity, and to a lesser extent factors thought to trigger physical activity behaviour (Biddle and Nigg, 2000; Crombie et al., 2004; Lees et al., 2005; Morris and Choi, 2005). Despite efforts to find ways to encourage physical activity, there is very little understanding of how people with T2DM think about being physically active, and how their attitudes towards incorporating physical activity into their self-management regimen can change. Gonder-Frederick et al. (2002) suggest many interventions which seek to address the problem of patient non-compliance to prescribed regimes, often focus on the target behaviour only. As a result interventions often fail to consider the influence of and interaction between other self-management behaviours such as monitoring diet, performing physical activity, taking medication and testing blood glucose levels (Collins et al., 2009). Further, to be effective in diabetes self-management, individuals must both initiate and maintain behaviours relating to the management of their condition in the context of daily life events and potentially, in the context of other chronic illness regimens (Piette and Kerr, 2006).

2.7.1 Motivation theories and models

Diabetes self-management is ongoing, and therefore motivation to adhere to self-care behaviours and regimen may be best conceptualised as a process rather than a specific goal (Sheldon et al., 2003). Many researchers believe that to realise the process of
changing health behaviours, people must be motivated to change (Resnicow, et al., 2001; Rollnick and Miller, 2005). How to identify, increase, and maintain this motivation is the challenge faced by those who wish to promote physical participation among the T2DM population.

Biddle and Nigg (2000) have described the application of motivational theories to physical activity behaviour, noting the most widely cited theories fit into four distinct categories: (i) competence-based theories, including Self-efficacy Theory; (ii) belief and attitude theories, including the Theory of Reasoned Action, the Theory of Planned Behaviour, and the Health Belief Model; (iii) control-based theories, such as Locus of Control and Self-determination Theory, and (iv) decision-making theories, which include the Transtheoretical Model.

The following sections of this review will focus on Self-efficacy Theory (Bandura, 1977), which in the context of physical activity behaviour, is amongst the most widely applied of the motivation theories. The review will then focus on the Transtheoretical Model (Prochaska and DiClemente, 1982), which has become increasingly popular within the area of physical activity behaviour promotion. Following this and in light of both the empowerment approach which recognises that patients are responsible for and in control of their important diabetes management decisions (such as appropriate medication adherence, dietary and physical activity choices), and the concept of self-management which attributes the patient with an ‘active participant’ role in treatment, it follows logically that the control-based theories, Locus of Control Theory (Rotter, 1966) and Self-determination Theory (Deci and Ryan, 1985) for which there is currently limited evidence within the context of physical activity adoption and maintenance among those with T2DM, will also be reviewed.

2.7.1.1 Self-efficacy Theory

Bandura (1977) proposed self-efficacy - a task-specific type of self-confidence - could predict behaviours. Self-efficacy Theory is informed by four main mechanisms; performance accomplishments, vicarious experiences, physiological arousal, and verbal persuasion (Bandura, 1986) illustrated in Figure 2.1.
Bandura (1986) argued performance accomplishments “provide the most influential source of efficacy information because it is based on authentic mastery experiences” (p. 399). Bandura (1986) proposed that failures with novel tasks markedly lowers efficacy for that task. If, however, a task has been successfully completed a number of times, infrequent failure at the task is unlikely to change efficacy perceptions for that task. The vicarious experience of modelling is exemplified where someone sees another person (often termed the “actor”) making a particular task look easy. The “modelling” effect occurs as the observer recognises the actor’s easy task accomplishment. Consequently the observer forms the perception that they too can perform the same task. Bandura argued that people convinced vicariously of their inefficacy are inclined to behave in ineffectual ways that, in fact, generate confirmatory behaviour evidence of inability. Conversely, modelling influences that enhance self-efficacy can weaken the impact of direct experiences of failure by sustaining performance in the face of repeated failure. Physiological arousal is another of the four main antecedent mechanisms influential for self-efficacy and relates to the tendency for people to interpret somatic symptoms, for instance racing heart, perspiration levels, or heavy breathing as signs of imminent danger possibly leading to thoughts of failure for the approaching task (Bandura, 1986). Bandura (1986) suggested this was because the fear of dysfunction that is generated by somatic arousal produces further thoughts of failure that exacerbates somatic arousal, and produces feared ineptitude. Somatic symptoms can result from participation in physical activities aimed at building strength such as weight training, or where breathing is difficult, for instance while running upstairs, or aches and pains after physical activity. The success of verbal persuasion is linked to the appraisal an
individual holds about their capability for a specific task. For instance, if there are self-doubts about their capabilities and a tendency to ruminate about personal deficiencies the persuasive efforts of a personal trainer or coach will need to be strong enough to counteract the self-doubt and rumination. Verbal persuasion aimed at raising self-efficacy depends on the setting of realistic goals for effectiveness because Bandura (1986) argued unrealistic beliefs can reduce the persuader’s credibility to the hearer. Bandura contended that all four self-efficacy mechanisms provide barriers or facilitators to motivation, mood and behaviour (Bandura, 2001).

The theory of self-efficacy proposes that patients’ confidence in their ability to perform health behaviours influences which behaviours they will engage in (Bandura, 1997; Lorig and Holman, 2003). Enhancing a patient’s confidence in their ability to successfully implement care is a critical step in promoting active self-management (Fu et al., 2003; Ismail et al., 2004). The self-efficacy model provides a useful framework for understanding and predicting adherence to self-care behaviours (Shortridge-Baggett, 2001). Among highly motivated patients, self-efficacy has been shown to be important for appropriate self-management among individuals with diabetes (McCaul et al., 1987; Kavanagh et al., 1993; Bernal et al., 2000; Aljasem et al., 2001). As diabetes self-management incorporates personal, behavioural, and environmental factors into daily performance of recommended self-management regimen ranging from diet and to medication taking and blood glucose monitoring, the concept of self-efficacy has received attention from researchers and clinicians attempting to further understand patient’s motives for behaviour. Studies have shown that a positive relationship exists between diabetes self-efficacy and self-care behaviour and that self-efficacy is a useful predictor of diabetes self-care behaviour (Hurley and Shea 1992; Glasgow et al., 1999; Via and Slayer, 1999; Williams and Bond, 2002; Fu et al., 2003; Ismail et al., 2004).

In the context of physical activity, higher levels of self-efficacy has been one of the most consistent predictors of greater levels of physical activity (Aljasem et al., 2001), reflecting individuals confidence in their ability to exercise (McAuley and Blissmer, 2000). Plotnikoff et al. (2009) investigated predicting aerobic and resistance training in a population of 244 adults with T2DM. Self-efficacy and age were significantly associated with resistance training, whereas response efficacy, self-efficacy, and age
were significantly related with resistance training intention. Self-efficacy was also found to be strongly associated with aerobic training expanding on previous work undertaken by Plotnikoff and colleagues where self-efficacy emerged as the most important factor predicting physical activity behaviour in a large population sample of adults (n=2311) with type 1 or T2DM (Plotnikoff et al., 2008).

While the conclusions which can be drawn from the Plotnikoff et al. (2008; 2009) studies is limited by the cross-sectional nature of the studies, more recent work undertaken by Plotnikoff et al. (2011b) further supports the apparent importance of self-efficacy and physical activity among individuals with diabetes. 244 participants completed questionnaires with a 3-month follow-up. Using regression models Plotnikoff and colleagues examined predictors of aerobic activity and resistance training finding that higher levels of aerobic physical activity were significantly associated with higher levels of self-efficacy (B=0.45, P<0.001). Similarly, higher levels of resistance training were also significantly associated with higher levels of self-efficacy (B=0.45, P<0.001).

Dutton et al. (2009) have also investigated whether self-efficacy mediated the relationship between participation in a 1-month print based individually-tailored physical activity intervention and improvements in physical activity levels among 85 T2DM participants. After controlling for age, baseline activity, and baseline self-efficacy, the tailored intervention was associated with significant improvements in physical activity, 95% CI [23.01 to 271.68] as well as self-efficacy, CI [0.02 to 3.48]. There was also an indirect effect of treatment on physical activity through self-efficacy, CI [0.77 to 73.11]. The direct effect of treatment on physical activity was no longer significant, CI [-7.33 to 253.40], after the influences of self-efficacy change were accounted for in the model. The results led Dutton and colleagues to conclude self-efficacy completely mediated physical activity among T2DM patients after a brief one-month intervention period.

Although the results support a mediation effect, the extent to which Dutton and colleagues suggest the treatment effect on physical activity was completely mediated by changes in self-efficacy, requires replication among a greater number of participants as well as longer term follow-up. The results do however further support
the theoretical rationale emphasising the importance of targeting self-efficacy to promote physical activity among patients with T2DM.

2.7.1.2 Transtheoretical Model

The Transtheoretical Model (TTM) (Prochaska and DiClemente, 1982) is a stage-based model in which individuals are at different stages of motivational readiness for engaging in behaviours to promote health and/or manage illness (Ruggiero et al., 1997). The TTM by Prochaska and DiClemente (1982) was initially applied to smoking cessation and other negative addictive habits, in order to further understanding of how people change their health behaviour. Subsequently, the application has been applied in the area of exercise behaviour (Marcus et al., 1992). The TTM proposes individuals progress through five stages when changing behaviour. The stages include: pre-contemplation, contemplation, preparation, action and maintenance as well as ‘relapse’ which describes the process of regressing one stage or more at a time. A physical activity specific definition of each stage is given in Table 2.6.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-contemplation</td>
<td>Not doing regular physical activity and have do not intend to become active in next 6 months</td>
</tr>
<tr>
<td>Contemplation</td>
<td>Not doing regular physical activity but thinking about becoming active in next 6 months</td>
</tr>
<tr>
<td>Preparation</td>
<td>Doing some physical activity but not enough to meet the description of regular physical activity</td>
</tr>
<tr>
<td>Action</td>
<td>Doing regular physical activity but only in the last 6 months</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Doing regular physical activity for longer than 6 months (behaviour change stabilised)</td>
</tr>
<tr>
<td>Relapse</td>
<td>Progression from one stage to another does not always occur and individuals can at any time progress backwards or relapse back one or a number of stages</td>
</tr>
</tbody>
</table>

The TTM of behaviour change is seen as a process rather than as a single event and therefore attempts to explain how, rather than why, behaviour change occurs (Prochaska et al., 1992). The model suggests that individuals do not change all at once, but instead move through a series of five stages. Each stage is defined by a temporal component related to the behaviour change. Research has also shown that the movement through the stages occurs in a cyclical manner and relapse can occur at any stage (Prochaska et al., 1992). A key characteristic of TTM is its
multidimensional design which includes not only the facet of the stages of change (SoC), but also the processes of change (strategies or techniques used to when changing behaviour), self-efficacy (confidence in ability to change), and decisional balance (pros and cons of change). As such the TTM’s main goal is to explain how health behaviour change occurs and to this end, 10 processes of change identified the strategies and techniques that people use to change their behaviour (Prochaska et al., 1988). These processes include obvious and more hidden activities that individuals use to modify their experiences and environments in order to modify their behaviour (Prochaska and Velicer, 1997). Furthermore the 10 processes of change can be divided into two categories labelled cognitive/experiential (i.e. consciousness raising, dramatic relief, environmental re-evaluation, self-re-evaluation, and social liberation) and behavioural/environmental (i.e. counter conditioning, helping relationships, contingency management, self-liberation, and stimulus control). The processes of change and related physical activity consultation are described in Table 2.7.

Table 2.7 Description of Processes of change components and related physical activity consultation description

<table>
<thead>
<tr>
<th>Processes of change component</th>
<th>Physical activity consultation strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experiential processes</strong></td>
<td></td>
</tr>
<tr>
<td>Consciousness raising</td>
<td>Providing information about the benefits of being more physically active and discuss the current physical activity recommendations</td>
</tr>
<tr>
<td>Dramatic relief</td>
<td>Discussing the risks of inactivity</td>
</tr>
<tr>
<td>Environmental re-evaluation</td>
<td>Emphasize the social and environmental benefits of physical activity</td>
</tr>
<tr>
<td>Self re-evaluation</td>
<td>Review of current physical activity status and assess values related to physical activity</td>
</tr>
<tr>
<td>Social liberation</td>
<td>Raise awareness of potential opportunities to be active and discuss how acceptable and available they are to the individual</td>
</tr>
<tr>
<td><strong>Behavioural processes</strong></td>
<td></td>
</tr>
<tr>
<td>Counter conditioning</td>
<td>Discussion of how to substitute inactive options for more active ones</td>
</tr>
<tr>
<td>Helping relationships</td>
<td>Seeking out friends, family, work colleagues who can support</td>
</tr>
<tr>
<td>Reinforcement management</td>
<td>Relapse prevention strategies such as rewarding successful attempts to be active</td>
</tr>
<tr>
<td>Self liberation</td>
<td>Goal setting: Making commitments for activity</td>
</tr>
<tr>
<td>Stimulus control</td>
<td>Relapse prevention: Identifying situations that may have a negative impact on physical activity behaviour change and developing ways to prevent relapse during these situations</td>
</tr>
</tbody>
</table>

(Adapted from Kirk et al., 2007)
In contrast to processes of change which focus on how behaviours can be changed, self-efficacy and decisional balance may be considered as helping to explain why health behaviour changes occur. Self-efficacy, taken from Bandura’s (1986) Social Cognitive Theory reflects the belief or the degree of confidence an individual has in his/her ability to perform a behaviour under a number of specific circumstances, in this instance, confidence that individuals have in performing the health behaviour change. As previously discussed, self-efficacy belief, is positively associated with an individuals ability to perform a specific behaviour (Bandura, 1977). Self-efficacy beliefs have been found to be associated with exercise performance (Sallis et al., 1986) and are related to stage of change, with precontemplators having the lowest self-efficacy levels and individuals in the maintenance stage possessing the highest level self-efficacy (Marcus and Owen, 1992). Meta-analyses have also shown that self-efficacy for exercise increase with each stage of change, but in a nonlinear pattern (Marshall and Biddle, 2001). More specifically, moderate effects were observed from precontemplation to contemplation, small to moderate effects from contemplation to preparation, moderate from preparation to action, and moderate to large effects from action to maintenance.

Similarly, decisional balance, an individual’s evaluation of the perceived benefits (pros) and barriers (cons) related to specific behaviours, help enhance the understanding of behaviour change (Prochaska and Velicer, 1997; Plotnikoff et al., 2001). Prochaska and Marcus (1994) suggests that pros and cons are reliable indicators for understanding current stage and predicting transitions between the SoC, and the weighing of the pros and the cons of engaging in healthy behaviours and is regarded as an important for early stage progression (Prochaska and Velicer, 1997; Nigg and Courneya, 1998). Early studies have suggested an association between an individual’s relative view of pros and cons and readiness for physical activity adoption (Marcus and Owen, 1992; Marcus et al., 1992). Prochaska (2008) suggests that pros (benefits) and cons (barriers) could be used as indicators of an individual’s motivation toward behaviour change and thus their progress through the SoC. For example, cons have a greater impact than pros among individuals at the precontemplation stage, whereas among individuals in the action or maintenance stages pros have a greater influence than cons.
Application of the TTM as a theoretical framework to develop behaviour change interventions requires an understanding of each dimension and how they interact with one another (Hutchison et al., 2009). Studies in the context of community groups (Marcus et al., 1998a), the workplace (Marcus et al., 1998b; Peterson et al., 1999), and primary care settings (Calfas et al., 1996; Dunn et al., 1998) have used the SoC framework, self-efficacy and decisional balance to further understanding of why individuals engage in and maintain physical activity behaviour. TTM researchers have included decisional balance as a hypothesized or implied predictor of physical activity behaviour (Cox et al., 2003; Plotnikoff et al., 2003; Towers et al., 2005). More recently, decisional balance has also been included as a psychological outcome or cognitive mediator within TTM-guided, physical activity intervention research (Plotnikoff et al., 2007). However, despite its central role in the TTM and its relevance to contemporary health and physical activity research, the specific measurement properties of instruments designed to assess physical activity-related decisional balance among individuals with T2DM has received limited investigational attention.

Although some studies have shown a relationship between physical activity levels and stage of change (Marcus et al., 1999, 2000; Kim et al., 2004) others have not (Naylor et al., 1999; Norris et al., 2000). Marcus et al. (1999) suggests that targeting interventions to individual stage of change for physical activity shows promise for achieving increased physical activity, enhanced readiness to adopt physical activity, and improved stage progress toward physical activity adherence. Marcus et al. (2000) examined TTM-based exercise interventions in people with T2DM. Their findings suggest that people who received a TTM intervention were more likely to increase their physical activity levels over a 6-month period. Kirk et al. (2004) further illustrated that over a 3-month period, participants with T2DM who received TTM stage-based counselling showed significant improvements in SoC for exercise behaviour, physical activity levels and HbA1c compared with a control group. While the TTM may have garnered support for its use among people with T2DM, some studies (Kirk et al., 2001, 2004), have only incorporated people in contemplation and preparation stages of behaviour change. Adams and White (2005) argue that for a staged matched programme to be effective, it needs to encompass people in all stages of activity change.
The TTM as a theoretical framework has proven popular in physical activity behaviour change interventions (e.g., Kirk et al., 2001, 2004, 2009). However, some researchers have questioned the effectiveness of TTM-based health promotion and physical activity interventions (Adams and White, 2005; Bridle et al., 2005). Adams and White (2005) suggest that TTM-based physical activity promotion interventions are reasonably effective in promoting behaviour adoption but have little influence on long-term adherence to increased activity levels. Bridle et al. (2005) reviewed seven physical activity behaviour change interventions and found only one in which the effect favoured the TTM-based intervention compared to usual care. A number of issues should be considered when using the TTM, as with any theoretical framework which purports to explain or predict behaviour change. First, physical activity behaviour is more complex than single behaviours such as smoking. For instance, individuals could be at a particular stage for one type of activity, and at another stage for a different activity (Adams and White, 2005). Interventions that view physical activity as a single behaviour may fail to recognise the complexity and specificity required for physical activity interventions. Second, Adams and White (2005) have emphasised the importance of accurately determining current stage of change, suggesting previous interventions lacked validated algorithms to assess current activity stage. Adams and White (2005) have also suggested physical activity behaviour may be influenced by a number of factors not considered by the TTM. For example, while the TTM focuses on personal motivation for behaviour change it does not take into account external factors such as age, gender, and social support. Finally, upon considering the multidimensional nature of the TTM Adams and White (2005) have suggested that previous behaviour change interventions may have adopted an overly simplistic approach. The suggestion is supported by Bridle et al. (2005) explaining many of the studies reported in their review of TTM-based health behaviour interventions offer incomplete representations of the model because they were tailored to focus on a single variable only, stage of change, neglecting the other dimensions of the model (processes of change, self-efficacy and decisional balance).

Further limitations of the TTM have been acknowledged more recently by Nigg et al. (2011). Nigg and colleagues suggest that in interpreting the strengths and weaknesses of the TTM in the context of physical activity behaviour, it is important to consider
that the TTM originally developed in the context of smoking cessation. As physical activity initiation and smoking cessation reflect contrasting intentions, it is important to recognise that TTM constructs can not be directly generalised to physical activity. Therefore Nigg et al. (2011) argue that many of the criticisms directed at the TTM in the context of physical activity are not fully merited, and instead efforts should be made to critically analyse adapted measurements of the scale to the physical activity context. However, alongside Armitage (2009), Nigg et al. (2011) also emphasise that caution is needed when evaluating the use of the TTM within physical activity, as unparalleled study designs, ineffective intervention strategies and failure to accurately represent all dimensions of the TTM means the efficacy of approaches and appropriateness of the underpinning model is not easily determined.

However, Hall and Rossi (2008) support the construct validity of the TTM following analysis of 120 separate studies dating from 1984 to 2003, across 48 health behaviours representing approximately 50,000 participants from 10 countries. Hall and Rossi (2008) reported the theoretical mechanisms for behaviour change described within the TTM were consistent across the range of behaviours and populations assessed supporting the application of the TTM to multiple behaviours including physical activity. A further strength of the TTM is its applicability to the targeting of multiple behaviours within a single intervention. Johnson et al. (2008) reported significant improvements in physical activity, healthy eating, weight management and emotional distress among adults randomly assigned to a fully tailored, TTM-based multiple behaviour intervention. The findings suggest a TTM-based intervention may help to develop a relationship between multiple health behaviours, whereby improvements in one aspect of behaviour may have beneficial effects on adherence and practice of other health behaviours. Such observations may have considerable public health implications as well as significant implications for individuals with T2DM who must manage multiple self-care behaviours simultaneously.

Another benefit of the TTM is that it provides the potential for an intervention to be individually tailored to appropriately fit an individual’s readiness for change with regard their physical activity behaviour. The individually tailored approach acknowledges that different people may be at different stages of change and therefore require different intervention approaches (Nigg et al., 2011). This also allows for a
greater number of individuals to be targeted simultaneously, for instance in population-based interventions, as well as providing a quick and practical way of assessing an individuals health behaviour and subsequently providing appropriate counselling for that individuals specific needs in order to assist their progression toward higher stages of change (Nigg et al., 2011).

2.7.1.3 Locus of Control Theory

Stemming from the Social Learning Theory approaches of behavioural psychologists in the 1950s and 1960s Rotter’s Locus of Control (LoC) Theory has been used to examine aspects of behaviour control (Rotter, 1954, 1966). Specifically, LoC refers to peoples’ perceptions and expectations about reinforcements for particular behaviours being contingent on individual forces or on forces outside of an individual. LoC has been used to explain outcomes such as metabolic control in terms of two factors: 1) internal LoC or personal effort, and 2) external LoC, inclusive of powerful others or chance. Tillotson et al. (1996) suggests most individuals with T2DM are stronger in one factor or another. Stenström et al. (1998) examined the relationship between LoC and treatment concordance in patients with type 1 diabetes suggesting individuals with high internal and low chance LoC had the best diabetes regimen concordance as measured by HbA1c.

Schlenk and Hart (1984) investigated a population of insulin dependent diabetes patients with diabetic foot ulcers. The study investigated LoC, health values, social support as well as patient concordance with varies aspects of diabetes management regimen (self-monitored blood glucose, exercise, diet, hypoglycaemic management, insulin administration and foot care). Research outcomes demonstrated a significant positive relationship between regimen concordance and internal LoC. It should be noted that participants in the Schlenk and Hart study were recruited from a diabetes outpatient clinic, which ran a self-care education programme which may explain the high concordance rates (participants performed in accordance with 70% of the aspects measured). When examining LoC in a population of type 1 diabetes patients, Coates and Boore (1995) found all participants reported to have high internal LoC. Although all the participants believed they were responsible for their own health, only one participant maintained blood glucose values within the normal range (3-5 mmol·l⁻¹). The findings might be explained by the complex differences between patients with
type 1 and patient with T2DM. While it could be argued that patients with type 1 diabetes assert greater control over their condition through an insulin injection regimen, which in turn may reinforce internal LoC, the findings likely emphasise the limitations of assessing and attempting to understand complex behaviour through the use of a single theoretical model or construct. This is consistent with Wallston’s (1991) view that LoC alone cannot predict health behaviours, but instead must be incorporated with other constructs such as Bandura’s (1977) self-efficacy construct.

Similarly O’Hea et al. (2005) has been critical of researchers investigating LoC suggesting inconsistent findings in the area result from the focus of researchers on internal LoC at the expense of fully examining powerful others and chance LoC dimensions. In 2005, O’Hea et al. performed a study examining the interactions between LoC dimensions and diabetes regimen concordance. The researchers suggested that while external LoC factors play a role in diabetes regimen concordance, it is internal LoC which is paramount in health behaviours. Subsequently, O’Hea et al. (2009) conducted a study that measured the interaction between LoC, self-efficacy, outcome expectancy and HbA1c in patients with T2DM. They found internal LoC to be important regarding diabetes management, but only when interacting with the two other perceived constructs – self-efficacy and outcome expectancy (O’Hea et al., 2009).

Trento et al. (2006) developed and tested a group-care technique among patients with T2DM. The technique utilised facilitators and a doctor to host group sessions 3-6 times·year⁻¹. The sessions involved practical activities, group work, problem-solving exercises, discussions and the sharing of feelings with others. Fifty-six patients, who had participated in group-care and 51 patients who had received individual medical education were given two questionnaires at the end of their programmes assessing general LoC (Wallston et al., 1978) and diabetes specific LoC (Peyrot and Rubin, 1994). Participants from the group-care intervention demonstrated lower chance and higher internal LoC. However, while the Peyrot and Rubin (1994) diabetes-specific questionnaire confirmed that group-care patients had higher internal LoC, the general Wallston et al. (1978) questionnaire did not. While the study demonstrated that group-care intervention may increase internal LoC, it is not clear whether higher internal LoC directly impacted improved levels of concordance – this may have been
influenced by other aspects of group-care such as more frequent health professional contact and advice reinforcement. Further, participant drop-out may have changed the characteristics of the cohort, where only the more motivated patients continued to attend the group-care sessions.

Subsequently, Trento et al. (2008) compared LoC among patients with either type 1 diabetes or T2DM who attended a group-care programme vs. a control group. Type 1 and T2DM patients were matched for of age, gender and duration of diabetes. The researchers observed patients with type 1 diabetes has lower internal LoC, and a greater belief that fate controls life events, in comparison to patients with T2DM. The group-care intervention decreased fatalist beliefs in both groups (type 1 and type 2) when compared with controls, as well as increase internal LoC among type 1 and type 2 patients. However, as before (Trento et al., 2006) these results were only found using the Peyrot and Rubin (1994) questionnaire and not the Wallston et al. (1978) questionnaire. While the authors do not refer to this difference, it may be due in part to the greater level of specificity offered by the Peyrot and Rubin (1994) diabetes specific questionnaire over the general LoC tool.

LoC, as it relates to diabetes management, has been the subject of interest in many studies, which unfortunately have been limited by their small sample sizes, highly variable results, and use of various measures of LoC. Some studies have found a positive relationship between internal LoC and glycaemic control (O’Hea et al., 2005; 2009), while, others have found a positive relationship between external locus of control and diabetes management (Kohlmann et al., 1993). A recent meta-analysis by Hummer et al. (2011) sought to determine if LoC correlated with metabolic control of diabetes. Specifically the meta-analysis investigated whether internal LoC, powerful others, or chance was correlated with how well people controlled their diabetes (gauged by assessment of HbA1c).

Seventeen articles met all inclusion criteria which included: adult participants with diabetes, use of HbA1c as a measure of glycemic control, measurement of a LoC scale, and a Pearson correlation (r) value (Hummer et al., 2011). Participants internal LoC (across 13 studies) was uncorrelated with HbA1c (r=-0.0099; 95% confidence interval [CI], −0.1092, 0.0893). Powerful others LoC (across 9 studies) was uncorrelated with
HbA\textsubscript{1c} (r=0.0928; 95% CI, −0.0136, 0.1993) and chance LoC (across 9 studies) was also uncorrelated with HbA\textsubscript{1c} (r=0.0926; 95% CI, −0.0398, 0.2250). Hummer et al. (2011) concluded there was no correlation between metabolic control and LoC, and at the very most there may be a weak correlation between metabolic control of diabetes and powerful others as well as chance LoC. However, as with many of the studies investigating LoC in the area of diabetes, the meta-analysis included studies which used HbA\textsubscript{1c} as the sole measure of metabolic control/regimen concordance failing to take into consideration the potential role LoC may have on other aspects of diabetes self-management and individual’s health status.

The validity of studies investigating the relationship between LoC and health-related behaviours have been further questioned due to the fact that an individual may have a tendency towards internality in many life areas, but have an external belief with regard to the particular health-related behaviour in question. McCready and Long (1985) tested the combined effects of LoC and attitudes towards physical activity with 61 female participants who voluntarily joined an 8 - 12 week aerobic fitness programme. McCready and Long (1985) found that a weak relationship existed between adherence to a fitness programme, internal LoC and attitude. However, upon investigating whether LoC concepts of internal and external control were influential for physical activity, Kennedy et al. (2001) found that individuals in the preparation stages of readiness to change their physical activity behaviour tended towards higher levels of internal LoC. Although there is limited evidence, the findings of Kennedy et al. (2001) again suggest there is merit in combining different theoretical perspectives to gain further understanding of motivation for physical activity behaviour.

2.7.1.4 Self-determination Theory
The Self-determination Theory (SDT) (Deci and Ryan 1985, 2000; Ryan and Deci 2002) provides a framework for understanding motivation and adherence to health behaviours, including physical activity. The basic principles of this theory are that human motivation varies in the extent to which it is autonomous (self-determined) or controlled, and that promoting long-term behaviour change implies an understanding of the internalisation process.
Deci and Ryan (1985, 2000) and Ryan and Deci (2002) have described how the SDT accounts for the quality of motivation regulating behaviour. The researchers suggest all humans possess an inherent tendency to integrate the regulation of extrinsically motivated activities. Deci and Ryan (1985) distinguish between intrinsic motivation (where the behaviour is engaged in for the enjoyment and satisfaction inherent in taking part), extrinsic motivation (where the behaviour is engaged in order to achieve outcomes that are separate from the behaviour itself) and amotivation (lacking any intention to engage in a behaviour). The process of integration lies on a continuum from non-self-determined amotivation, to the lower (extrinsic motivation) and higher autonomously self-determined forms (illustrated in Figure 2.2).

<table>
<thead>
<tr>
<th>Type of motivation</th>
<th>AMOTIVATION</th>
<th>EXTRINSIC</th>
<th>INTRINSIC</th>
</tr>
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<tbody>
<tr>
<td>Type of regulation</td>
<td>Non-regulation regulation</td>
<td>External regulation</td>
<td>Identified regulation</td>
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<tr>
<td>Quality of behaviour</td>
<td>Non-self-determined</td>
<td>Self-determined</td>
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Figure 2.2 The Self-determination continuum, with types of motivation and types of regulation (Adapted from Ryan and Deci, 2002)

The least autonomous form of motivation is labelled external regulation, and occurs when a person performs activities either to obtain rewards, or to avoid punishment or sanctions. Introjected regulation involves internalising the behaviour’s regulation, but not fully accepting it as one’s own (behaviours are performed to avoid negative emotions such as anxiety and guilt, supporting conditional self-worth). Identified regulation reflects participation in an activity because one holds outcomes of the behaviour to be personally significant and important (although one may not enjoy the activity itself). Intrinsic, a highly autonomous form of motivation is present when an activity is engaged because of its inherent satisfaction such as for the fun, interest, or the challenge it offers (Deci and Ryan, 1985, 2000; Ryan and Deci, 2002).

The SDT also describes the processes that facilitate motivational development by indicating that more controlled regulations can be internalised and transformed into autonomous motivation, if supportive conditions are in place. Ryan and Deci (2002)
describe supportive conditions as necessary to foster the satisfaction of basic needs for autonomy (feeling volitional and feeling choice and responsibility for one's behaviour), relatedness (feeling understood, cared for and valued by significant others), and competence (feeling that one can accomplish the behaviours and reach the goal). When the three basic needs are met, more self-determined forms of motivational regulation guiding behaviour and adaptive behavioural (e.g., physical activity engagement), cognitive (e.g., commitment) and well-being (e.g., joy) outcomes are hypothesized to follow (Ryan and Deci, 2002). In contrast, Deci and Ryan (2000) suggest that although people have an inherent propensity toward maintaining their well-being, this natural tendency can be thwarted by conditions that frustrate the satisfaction of three basic psychological needs.

The SDT postulates that formerly controlled motivation can be internalised and transformed into autonomous motivation, if supportive conditions are in place. Vallerand (2001) has focused on the psychological nutrients that engender adaptive motivational, behavioural, cognitive, and affective outcomes, by specifying contextual variables that facilitate (or hinder) these processes. For example, the way a person acts in a particular situation cannot be attributed only to individual differences, as contextual variables may also exert a significant influence as illustrated in Vallerand’s (2001) hierarchical model of intrinsic and extrinsic motivation (Figure 2.3).

Vallerand (2001) emphasised that it is no longer sufficient to refer unilaterally to motivation instead we must appreciate that people are motivated at various levels and in different ways for different behaviours. For example, one may be extrinsically

<table>
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<tr>
<th>Levels</th>
<th>Social factors</th>
<th>Psychological mediators</th>
<th>Hierarchical levels of motivation</th>
<th>Consequences</th>
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</thead>
<tbody>
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<td>Global factors</td>
<td>Autonomy</td>
<td>Global motivation</td>
<td>Affect Cognition</td>
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<td></td>
<td></td>
<td>Competence</td>
<td>IM, EM, AM</td>
<td>Behaviour</td>
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<td></td>
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<td>Relatedness</td>
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<tr>
<td>Contextual – life domain</td>
<td>Contextual factors</td>
<td>Autonomy</td>
<td>Contextual motivation</td>
<td>Affect Cognition</td>
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<td>Competence</td>
<td>Interpersonal relations</td>
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<td>Situational – state</td>
<td>Situational factors</td>
<td>Autonomy</td>
<td>Situational motivation</td>
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Figure 2.3 Hierarchical model of intrinsic and extrinsic motivation (Adapted from Vallerand, 2001)

KEY: AM, amotivation; EM, extrinsic motivation; IM, intrinsic motivation.
motivated to be physically active on a sunny day, when enjoying time off work (state), but be amotivated for climbing stairs when carrying heavy bags of groceries (contextual). Further, intrinsic and extrinsic motivation are constructs that researchers have presented as dichotomous but in reality there is no clear division and interactions operate at all levels (Ryan and Deci, 2002). In the context of health, socioeconomic environmental conditions that facilitate the satisfaction of these needs will promote the internalisation of protective and preventive health behaviours so that they are engaged in autonomously and more likely to be maintained in the long term (Deci and Ryan, 2000).

Research utilising SDT has shown that the degree of autonomous motivation is associated with improved attendance, greater reductions in BMI, and improved maintenance at the 23-month follow-up within a weight loss programme (Williams et al., 1996), and also with several other health outcomes such as improved glycaemic control, dietary self-care and regular exercise (Williams et al., 1998a) and long-term medication adherence (Williams et al., 1998b) in diabetes patients. These studies indicate that being autonomous in one’s actions is a crucial predictor of maintained behaviour change. This also holds true in the context of physical activity, where research has shown that more autonomous regulatory motives are conducive to higher long-term physical activity adherence (Fortier et al., 2007).

Autonomous motivation has been found to be not only predictive of change in several health conditions, but it is also modifiable from an intervention standpoint. Studies have confirmed the effectiveness of manipulating the social–contextual variables proposed by SDT in the context of smoking cessation (Williams et al., 2006) and physical activity promotion in several contexts, such as sports centres (Edmunds et al., 2008), in school (Wilson et al., 2005; Chatzisarantis and Hagger, 2009) and in healthcare services (Fortier et al., 2007). Testing the SDT model in the context of physical activity and diabetes self-management Williams et al. (2004) recruited 159 participants from a diabetes centre. Participants completed information on several motivation variables including autonomous motivation and perceived competence for diet and exercise. These variables were measured at baseline, 6 months, and 12 months. Williams et al. (2004) provided the example for an autonomous motivation for diet and exercise question as “I’ve carefully thought about my diet and exercise
and believe they are the right thing to do”. Participants responded on a 6-point Likert scale. They also reported on six items that were taken from the Treatment Self-Regulation Questionnaire (Ryan and Connell, 1989). Four items from the Perceived Competence for Diabetes Scale (Williams et al., 1998a) were also used to assess how well patients felt they managed their daily self-care. Williams et al. (2004) reported changes leading to higher levels of autonomy and perceived competence led to improvements in HbA1c levels. Dacey et al. (2008) provided additional evidence of the motivational role of perceived enjoyment of physical activity in older adults (n=645; mean age of 63.8). Exercise motivation was measured using the Exercise Motivations Inventory 2 (EMI-2) and stage of change scales. Dacey et al. (2008) reported that for the six factors including; health and fitness, social and emotional benefits, weight management, stress management, enjoyment, and appearance, the enjoyment factor loaded the most strongly for differentiating physical activity levels.

More recently Williams et al. (2009) have investigated the application of SDT to predict medication adherence, quality of life, and physiological outcomes among patients with diabetes. Participants (n=2973) of the study who received care from an integrated healthcare delivery system in 2003 and 2004 were identified from automated databases and invited to participate. In 2005, participants responded to a mixed telephone-and-mail questionnaire assessing perceived autonomy support from healthcare providers (using the Health Care Climate Questionnaire), autonomous self-regulation for medication (using the Treatment Self-Regulation Questionnaire), perceived competence for diabetes self-management, medication adherence, and quality of life. The participants were then followed-up one year later. Data pertaining to participant pharmacy claims were used to indicate medication adherence, and patients’ HDL-C, HbA1c, and glucose levels were also assessed. The SDT model of health behaviour provided adequate fit to the data. As the researchers had hypothesised, perceived autonomy support from healthcare providers related positively to autonomous self-regulation for medication use, which in turn related positively to perceived competence for diabetes self-management. Perceived competence related positively to quality of life and medication adherence, and was inversely related to HDL-C, HbA1c, and glucose levels. In conclusion, Williams et al. (2009) suggested healthcare providers’ support for patients’ autonomy and competence around
medication use was positively related to patient’s diabetes self-management, medication adherence, quality of life, and physiological outcomes.

2.7.2 Summary of theories and models
Different theoretical approaches offer different perspectives on understanding and changing behaviour. Self-efficacy researchers have shown techniques, such as, realistic goal setting and social support, are central to enhancing self-efficacy. While it is important to recognise different types of efficacy for different behaviours such as exercise or diet, vicarious experience may prove useful as a form of self-modelling, and verbal persuasion when linked to someone considered trustworthy and or knowledgeable may enhance self-efficacy. The TTM represents an intuitively appealing model of the change process and has been used to challenge previous research findings focused exclusively on linear models of change. Central concepts of the multidimensional TTM include SoC, processes of change, self-efficacy, and decision-balance. While the TTM has been used to assess to physical activity level, and intervention research has shown the utility of the TTM in short-term interventions, evidence supporting its use in the promotion and maintenance of physical activity is less convincing. Most of the research conducted to investigate LoC in the context of health, have demonstrated that participants with higher internal LoC have better concordance with medical regimen and overall better health outcomes. Research investigating LoC in the context of diabetes also suggests the specificity of measurement tool used to assess LoC is an important consideration particular given the complex nature of managing multiple behaviours simultaneously - a common feature of individuals with T2DM self-care regimen. The SDT offers perceptions of autonomy, competence, and relatedness linked with intrinsic, extrinsic, and amotivation, within global, situational and contextual levels to help explain behaviour motivation. In relation to physical activity interventions founded on SDT, researchers have highlighted the utility of the formation of enduring goals, social support, and the identification of autonomous action and freedom of choice, task mastery, and intrinsic rewards. Individual theories and models may facilitate further understanding of motivation for physical activity, but given the complexity of this behaviour, improved understanding of why and how individuals initiate and maintain physical activity will more likely be gained through use of such theories and models in unison rather than in isolation. It should also be acknowledged that investigating
physical activity behaviour among individuals with T2DM within a framework of theories and models alone may overlook important barriers or facilitators for the behaviour. For instance, the importance of identifying the type of advice or support that people prefer to assist them in initiating or maintaining physical activity as well as the types of physical activities people are willing to adopt and maintain may be ignored. Finally, it should be noted that similarly to the measurement of physical activity levels, any investigation which focuses on theories and models, despite using validated questionnaires and scales, must often rely on subjective self-report methods. Such procedures may be exposed to bias and therefore both their effectiveness and outcomes should be considered with caution (Asimakopoulou and Hampson, 2005).

2.8 Barriers and facilitators to physical activity

Models and theories of health can provide a framework for examining influences on behaviour. Sallis and Owen (1999) suggest that models often posit multiple levels of influence on behaviour and include, for example, factors at the personal level preventing people from being physically active (e.g. lack of time), barriers at the social level (e.g. family and work demands), and barriers at the environmental level (e.g. poor access to physical activity facilities). Extensive research has been conducted examining these barriers within healthy populations (Wendel-Vos et al., 2007) however, barriers among those with abnormal glucose metabolism, such as impaired fasting glucose and impaired glucose tolerance (IGT) or those diagnosed with T2DM are less well researched. Cross-sectional research among US adults performed by Rhodes and Blanchard (2007) suggested there are some differences in physical activity cognitions and barriers between people with and without T2DM. This is important, as knowledge of a chronic health condition is likely to influence perceived barriers to physical activity and thus explain differences in physical activity levels between those with or without T2DM (Ekelund et al., 2009). However, the outcome of a recent study undertaken by Hume et al. (2010) suggests that adults with normal glucose metabolism report similar barriers to physical activity as those with abnormal glucose tolerance. Hume et al. (2010) suggest programmes for those with abnormal glucose metabolism should focus on known adult-reported barriers to physical activity. However, given that individuals with normal glucose tolerance (NGT) and T2DM alike are afflicted by physical inactivity, efforts based on non-
individualised generic participant barriers may continue to fail to alleviate sedentary behaviour among either population.

Central to the successful use of physical activity in the self-management of T2DM is identification of patient’s perceived barriers and facilitators to the behaviour. The identification of barriers may create an opportunity for individuals to find solutions to such barriers and in turn allow them to focus more strongly on facilitators of the behaviour. Alongside models of theories explaining behaviour, increased knowledge and understanding pertaining to barriers is also critical to the development of effective exercise counselling, and design of methods and campaigns aimed at motivating sedentary individuals with T2DM to become and remain physically active.

In a review of studies investigating physical activity behaviour among individuals with T2DM undertaken by Korkiakangas et al. (2009) barriers to regular physical activity or exercise were identified as either internal or external. Internal barriers included factors which could be influenced by the individual’s own decision-making, such as, lack of time and emotions such as shame (Swift et al., 1995; Shultz Armstrong et al., 2001; Mier et al., 2007), laziness (Van Rooijen et al., 2002; Dye et al., 2003; Mier et al., 2007; White et al., 2007) and fear of exercise (Swift et al., 1995; Wanko et al., 2004; Donahue et al., 2006; Lawton et al., 2006; Mier et al., 2007). The authors suggested individuals feel that there are inadequate reasons, goals and benefits of exercise (health problems, exercise is not motivating) in addition to the costs of exercising (pain, tiredness, feeling that exercise is uncomfortable, negative emotions). The Korkiakangas et al. (2009) review concluded that poor health or being overweight was at the root of these feelings. For example, individuals who were overweight often found exercise both emotionally and physically uncomfortable (Swift et al., 1995; Shultz Armstrong et al., 2001; Mier et al., 2007). Difficult life situations were also presented as barriers to exercise (Searle and Ready 1991; Van Rooijen et al., 2002; Thomas et al., 2004; Dutton et al., 2005; Mier et al., 2007) - the most commonly reported being lack of time (Searle and Ready, 1991; Shultz Armstrong et al., 2001; Van Rooijen et al., 2002; Thomas et al., 2004; Dutton et al., 2005; Donahue et al., 2006; Lawton et al., 2006; White et al., 2007).
Korkiakangas et al. (2009) presented external barriers as factors which were distinct from an individual’s inner decision-making, such as weather (Shultz Armstrong et al., 2001; Thomas et al., 2004; Lawton et al., 2006; White et al., 2007; Mier et al., 2007; Serour et al., 2007) or cultural barriers (Van Rooijen et al., 2002; Lawton et al., 2006). These factors prevented exercising through, lack of exercise facilities (Searle and Ready, 1991; Mier et al., 2007), lack of social support (Searle and Ready, 1991; Dutton et al., 2005) and also diminished motivation for exercise (Korkiakangas et al. (2009). The suggestion that perceived barriers to exercise also effects motivation for the behaviour has important implications for models and theories which purport to explain motivation as well as for interventions which seek to promote physical activity initiation and maintenance.

Research investigating factors thought to effect physical activity behaviour has lead to the creation of a ‘list’ of perceived barriers and facilitators to exercise behaviour specific to individuals with T2DM. However, the relationship between such barriers and facilitators and an individual’s motivation to initiate and maintain physical activity or exercise is not yet clear. There is currently a paucity of research investigating how barriers and facilitators act to motivate lifestyle changes such as exercise behaviour, among those with T2DM. A previous study investigating facilitators and barriers for regular exercise among individuals at high risk of developing T2DM in a psychosocial context (Donahue et al., 2006) suggests motivators for exercising were high-priority and self-efficacy related to exercise, beliefs regarding weight control by activity, receiving social support, sufficient free time for exercise and being less worried about injuries. In the review by Korkiakangas et al. (2009) two studies eluded to the role of both social and psychosocial factors in motivating those with diabetes to exercise. According to Van Rooijen et al. (2002) better health, quality of life, better glucose control and fun were presented as facilitators for exercise. While Mier et al. (2007) presented well-being, looking better and family support as facilitators for exercise among individuals with diabetes. Ferrand et al. (2008) has gone further stating the motives for physical activity include both social and psychological motives. Social motives include a welcoming and friendly atmosphere, conducive to respect for others or a feeling of being understood and supported by others. Moreover, psychological motives include an improved sense of well-being, promotion of health benefits and a positive body image. Ferrand et al.
(2008) also suggest social and psychological motives for regular exercise in adults with T2DM are subject to gender differences. For example, female participants emphasised the importance of emotional support, pleasure of doing something together, sense of well-being and positive body image. In contrast, for male participants, motives for regular exercise included knowledge acquisition and skill development for disease control and the strength of the relationship between physical activity and health-promoting behaviours. Korkia Kangas et al. (2011) investigated motivators and barriers to physical activity among individuals diagnosed with or at risk of T2DM. The qualitative study suggested motivators to physical activity included weight management, feelings of physical and mental well being. In addition, social relationships associated with exercise were also motivators. Further, the authors concluded that regular counselling was important in order to promote exercise among older people, and that motivators to exercise are strengthened by positive experiences of exercise as individuals grow older.

The mechanism by which barriers and facilitators impact motivation and lead to inactivity or the adoption and maintenance of activity behaviour have not being fully investigated. In contrast much research has simply led to a growing list of barriers and facilitators thought to impact the behaviour among those with T2DM which in turn has not led to a reduction in sedentary behaviour among this population. While the barriers and facilitators affecting physical inactivity reported by individuals with T2DM may in some instances be similar to those reported by adults with normal glucose metabolism it is plausible that simply creating a generic list of barriers and facilitators simply undermines the undoubted progress which has led to the development of specific physical activity guidelines currently available for both individuals with T2DM (Colberg et al., 2010) and other clinical and healthy subsets within the wider population (O’Donovan et al., 2010). Optimistically, it is also possible that theories and models of health behaviour such as self efficacy theory (Bandura, 1986) and the SDT (Ryan and Deci, 2002) can be used to compliment the advances made in the development of guidelines and increase understanding of how factors - barriers and facilitators, internal and external - influence individuals motivation for regular physical activity and exercise.
2.9 Summary

T2DM is a chronic condition which upon diagnosis requires the patient to undertake daily self-management for the rest of their life. A continually growing evidence base initially focused on aerobic exercise interventions, which remain prominent, and expansion into research investigating resistance exercise alone or a combination of both aerobic and resistance has led to a greater understanding of the relationship between physical activity and T2DM. Interventions involving structured exercise training and physical activity advice have been found to be effective in improving glycaemic control and other cardiovascular risk factors among individuals with T2DM. While these two approaches appear to be effective in the form of controlled interventions their feasibility in real-world scenarios is much less clear and current physical activity recommendations reflect this by appearing to combine features from both structured exercise and physical activity advice interventions to produce guidelines which are more widely achievable and accessible to the T2DM population as a whole. The application of different theories and models and investigation of barriers and facilitators has also enhanced understanding of the factors which may effect initiation and maintenance of physical activity behaviour. However, despite the growing evidence base and understanding and the continued development of guidelines the majority of T2DM patients do not achieve the recommended levels for physical activity behaviour.

The evolution and progression of physical activity guidelines for the T2DM population is indicative of the use aspects of structured exercise, physical activity advice, and theories and models from the growing evidence base. The growth of physical activity research within the area of T2DM reflects not only the conflicting nature of how to best approach diabetes management through the use of physical activity but also a movement away from a ‘one size fits all’ approach to promoting physical activity behaviour. Given the complex manner by which physical activity behaviour is initiated and maintained, continued research is critical if we are to meet the challenges presented by this increasingly endemic chronic condition. In conclusion, recognising the strengths and limitations of structured exercise, physical activity advice, and the theories and models of behaviour, further research is needed to develop more specific and direct methods of assisting those with T2DM to initiate and maintain physical activity and exercise to manage their condition. Focus should
be placed on investigating; individualised prescription and support, the role of physical activity advice for achieving recommended guidelines, and, how models and theories may help understanding of behavioural outcomes rather than simply describing cognitive processes.
Chapter 3

The effect of a supported exercise programme in patients with newly diagnosed type 2 diabetes mellitus
3.1 Introduction
The following chapter describes an exercise intervention for a group of newly diagnosed type 2 diabetes mellitus (T2DM) patients detailing the methods used, study results, followed by in depth discussion of the findings, and their implications for future research and practice. Baseline and post-intervention, 3-month, findings have been published and a full paper is available in Appendix 1.

3.1.1 Overview
It is well established that T2DM constitutes a significant risk for the development of cardiovascular disease (CVD) (Blair et al., 1995). This can be partly explained by the simultaneous presence of risk factors such hyperglycaemia, obesity, insulin resistance and dyslipidaemia among diabetes patients (UKPDS, 1998). An increasing body of evidence supports the use of physical activity interventions in the management of T2DM to improve glycaemic control, reduce the risk of microvascular and macrovascular complications, and increase insulin sensitivity (Boule et al., 2001; Dunstan et al., 2002; Goldhaber-Fiebert et al., 2003). Physical activity has also been advocated in the reduction of stress and risk of depression (Anderson et al., 2001), as well as contributing to weight loss/maintenance (Klein et al., 2004). The contribution of physical activity to control of lipids and blood pressure, thereby reducing the risk of cardiovascular disease, the leading cause of death in diabetes patients (Albright et al., 2000; Sigal et al., 2004; Pedersen and Saltin, 2006) is also widely recognised.

The goal of treatment in T2DM is to achieve and maintain optimal blood glucose, lipid and blood pressure levels to prevent or delay chronic complications of diabetes (ADA, Standards of Medical Care in Diabetes - 2010). Based on available evidence diabetes specific physical activity recommendations and guidelines have been produced by a number of bodies including the American College of Sports Medicine (ACSM) (Albright et al., 2000), the ADA (Sigal et al., 2006), and a joint position stand from the ACSM and the ADA (Colberg et al., 2010). It is recommended that individuals with T2DM engage in at least 150 min-week\(^{-1}\) of moderate-intensity aerobic physical activity (40-60% of VO\(_{2}\)\(_{\text{max}}\) or 50-70% of maximum heart rate) and/or at least 90 min-week\(^{-1}\) of vigorous aerobic exercise (>60% of VO\(_{2}\)\(_{\text{max}}\) or >70% of maximum heart rate). The physical activity should be distributed over at least 3 days-week\(^{-1}\) and with no more than 2 consecutive days without physical activity. In
the absence of contraindications, individuals with T2DM should be encouraged to perform resistance exercise at moderate intensity (50% 1-repetition maximum [1-RM]) or vigorous (75-80% 1-RM) two-three times week$^{-1}$. Each training session should minimally include 5-10 exercises involving all major muscle groups progressing to three-four sets of 10-15 repetitions or use of heavier weights (or resistance) that can be lifted only 8-10 times.

Despite research that substantiates the prevention and/or delay in complications for diabetes patients who engage in even moderate activity, as well as endorsement of physical activity by a number of bodies diabetes patients often report that they are not regularly active (Kavookjian et al., 2005). Initiating and maintaining physical activity behaviour remains problematic (Kavookjian et al., 2007). A review of public health interventions aimed at increasing physical activity levels among sedentary adults found that although activity levels often do not reach public health recommendations, increases in activity levels can be found among interventions which have a common set of attributes (Hillsdon et al., 2005). Provision of individually tailored advice, goal-setting, self-monitoring, the promotion of moderate-intensity activity and provision of professional guidance about starting an exercise programme followed by ongoing face-to-face support may be more effective in encouraging the uptake of physical activity (Hillsdon et al., 2005). Supported programmes administered over several weeks can improve physical ability and diabetes control in the short-term (Dunstan et al., 2002; Goldhaber-Fiebert et al., 2003) however little is known about their long-term effectiveness or how they compare to exercise in unsupported or standard care settings. Short unsupported programmes that encourage people to exercise at home or in a fitness centre without one-to-one contact with an exercise practitioner may be more feasible and cost-effective than supported exercise programmes, but their effectiveness is unknown. Alam et al. (2004) investigated supported and unsupported exercise among patients with T2DM and found unsupported exercise had no significant effect.

Although the benefits of physical activity are widely recognised (Sigal et al., 2004) and exercise specific guidelines and recommendations for those with T2DM have been established (ACSM and ADA joint position stand, Colberg et al., 2010), there are substantial research gaps for healthcare providers who wish to engage patients in a
physical activity regimen. Low levels of participation in physical activity among this population remain, and there is limited research investigating the benefits of supported and unsupported exercise programmes for patients, in particular those with newly diagnosed T2DM.

3.1.2 Study objectives

3.1.2.1 General objective
This randomised controlled trial aimed to investigate the effectiveness of an unsupported exercise programme (akin to standard care) (SCP) in comparison to a 12-week supported exercise programme (SEP) during the 3-month period following initial diagnosis among T2DM patients, with repeated measures at 1 year follow-up.

3.1.2.2 Specific objective
To investigate the effectiveness of a 12-week SCP and a 12-week SEP on glycaemic control, β-cell responsiveness, insulin resistance and lipid profiles during the 3-month period following initial diagnosis in T2DM patients.

3.2 Methods

3.2.1 Participants
The validated software G*Power (version 3.0) (http://wwwpsycho.uniduesseldorf.de/abteilungen/aap/gpower3) was used to establish required sample size for the present study. In this instance the following selections were made:

**Test family**: t tests

**Statistical test**: Means: Difference between two independent means (two groups)

**Type of power analysis**: A priori - compute required sample size - given alpha, power, and effect size

- **Tail (s)**: one
- **Effect size**: 0.8 (large effect size)
- **Alpha error probability**: 0.05
- **Power**: 0.95
- **Allocation ratio N2/N1**: 1

The software provided a required a total sample size of 70, consisting of two groups of 35 participants.
Following a two-year recruitment period thirty treatment naïve newly diagnosed T2DM patients were recruited from a diabetes clinic at Llandough Hospital, Cardiff, Wales. Exclusion criteria included current treatment with oral anti-diabetic drugs (OADs) or insulin, and severe complications of diabetes, such as evidence of hepatic disease. Other exclusion criteria included changes of ischaemia or cardiac disease at rest or during an exercise tolerance test identified by electrocardiogram (ECG), problems with mobility, current use of anti-inflammatory drugs, severe asthma, taking corticosteroids, thyroxine or growth hormones.

Of the thirty patients recruited, none of the participants had previously participated in an exercise intervention. Nine participants were excluded due to cardiac anomalies observed during the exercise tolerance test (adapted Bruce protocol, Dwyer and Davis, 2004). Twenty-one participants were randomised to one of two study arms: 1) Standard Care Programme (SCP) 2) Supported Exercise Programme (SEP). Of the twenty-one patients who commenced the 12 week intervention one patient dropped-out of the SEP whilst one patient was discontinued from the SCP after requiring medical attention following a hyperglycaemic event not related to exercise. Both patients’ whose baseline variables were within 1 SD of their respective groups were removed from the final analysis. A total of nineteen patients (SEP, n=10; SCP, n=9; male, n=15; female, n=4; aged=59.6[44.0-69.0] years) completed the 12-week intervention. Nine (SEP, n=5; SCP, n=4) participants were followed up at 1-year post-intervention. Figure 3.1 provides an overview of the study design at baseline, intervention completion and 1-year follow-up.

The experimental protocol was approved by the South East Wales Research Ethics Committee and the University of Wales Institute Cardiff Ethics Committee. All participants received written and verbal information regarding the nature and potential risks of the study and they were required to provide signed informed consent prior to participating (Appendices 2, 3).
3.2.2 Exercise intervention

Patients in the SCP were advised to exercise at moderate- to high-intensity five 30-min sessions·week\(^{-1}\) for a period of 12-weeks (as per standard care). The 12-week SEP consisted of three 60-min exercise sessions·week\(^{-1}\), plus two unsupported exercise sessions per week (totalling five sessions·week\(^{-1}\)). All supported exercise sessions were overseen by a qualified exercise physiologist. During the supported exercise sessions individualised exercise intensities were determined using the heart rate reserve (HRR) method (Karvonen et al., 1957). Each supported exercise session commenced and finished with warm-up (10-min) and cool-down (5-min) periods performed at an intensity of 40-50% HRR. During weeks 1 and 2 the cardio-respiratory phase consisted of 20-min steady state activity at an intensity of 60-75% HRR on a bicycle ergometer (W1 Original Ergometer Electronics, Tunturi, Finland). Following the introductory period of weeks 1 and 2, the cardio-respiratory phase progressed to 20-40 min periods of interval training (weeks 3-12). Interval training consisted of 1- to 2-min low intensity periods at 40-50% HRR and high intensity

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Figure 3.1 Visit schedule (MTT, meal tolerance test; FSIVGTT, frequently sampled intravenous glucose tolerance test)
periods of 1-, 2- or 3-min at 80-90% HRR. All participants in the SEP group were advised to complete two additional exercise bouts a week, outside the supported environment. Both groups were asked to keep a record of the unsupported exercise sessions in a training diary (Appendix 4). No specific exercise intensities were given to the SCP group so that this advice remained within standard care. In addition, participants in the SCP were telephoned every other week, as advised by the ethics committee, to check on progress.

### Table 3.1 Descriptive characteristics of 12-week supervised exercise programme (sessions 1-36)

<table>
<thead>
<tr>
<th>Week</th>
<th>Session</th>
<th>Prescription</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1-3</td>
<td>20 min SS - 60-70% HRR</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>25 min SS - 60-70% HRR</td>
</tr>
<tr>
<td>2</td>
<td>5-6</td>
<td>25 min SS - 65-75% HRR</td>
</tr>
<tr>
<td>3</td>
<td>7</td>
<td>16 min IT. 2:2 min - 80-90% HRR:40-50% HRR</td>
</tr>
<tr>
<td>3-4</td>
<td>8-10</td>
<td>20 min IT. 2:2 min - 80-90% HRR:40-50% HRR</td>
</tr>
<tr>
<td>4</td>
<td>11</td>
<td>25 min SS - 60-70% HRR</td>
</tr>
<tr>
<td>4</td>
<td>12</td>
<td>20 min IT. 2:2 min - 80-90% HRR:40-50% HRR</td>
</tr>
<tr>
<td>5</td>
<td>13-15</td>
<td>20 min IT. 3:2 min - 80-90% HRR:40-50% HRR</td>
</tr>
<tr>
<td>6</td>
<td>16</td>
<td>Nutrition class</td>
</tr>
<tr>
<td>6</td>
<td>17-18</td>
<td>25 min IT. 3:2 min - 80-90% HRR:40-50% HRR</td>
</tr>
<tr>
<td>7</td>
<td>19-20</td>
<td>30 min IT. 3:2 min - 80-90% HRR:40-50% HRR</td>
</tr>
<tr>
<td>7</td>
<td>21</td>
<td>25 min IT. 3:2 min - 80-90% HRR:40-50% HRR</td>
</tr>
<tr>
<td>8</td>
<td>22-24</td>
<td>30 min IT. 3:2 min - 80-90% HRR:40-50% HRR</td>
</tr>
<tr>
<td>9-10</td>
<td>25-29</td>
<td>35 min IT. 3:2 min - 80-90% HRR:40-50% HRR</td>
</tr>
<tr>
<td>10</td>
<td>30</td>
<td>20 min IT. 1:1 min - 80-90% HRR:40-50% HRR</td>
</tr>
<tr>
<td>11</td>
<td>31-32</td>
<td>40 min IT. 3:2 min - 80-90% HRR:40-50% HRR</td>
</tr>
<tr>
<td>11</td>
<td>33</td>
<td>20 min IT. 1:1 min - 80-90% HRR:40-50% HRR</td>
</tr>
<tr>
<td>12</td>
<td>34</td>
<td>Circuit training</td>
</tr>
<tr>
<td>12</td>
<td>35</td>
<td>40 min IT. 3:2 min - 80-90% HRR:40-50% HRR</td>
</tr>
<tr>
<td>12</td>
<td>36</td>
<td>40 min IT. 3:2 min - 80-90% HRR:40-50% HRR</td>
</tr>
</tbody>
</table>

KEY: HRR, heart rate reserve; IT, interval training; SS, steady state activity.

### 3.2.3 Carbohydrate challenge tests

For both carbohydrate challenge tests blood was collected from an indwelling polyethylene intravenous cannula situated in an antecubital fossa vein. After inserting the cannula, a three-way tap was connected through which ran a slow running saline drip to keep the vein patent. A standard meal tolerance test (MTT) was performed which consisted of a 500 kcal mixed meal (58% carbohydrate, 22% protein, 20% fat), as previously described by Peter et al. (2006). Fasting blood samples were taken at -30 min and at 0 min. Following the 0 min sample the standardised meal was given to the patient and consumed within 10 min. Blood samples were then taken at frequent intervals over the following 4-hours (10, 20, 30, 40, 50, 60, 75, 90, 120, 150, 180, 210 and 240 min). Samples taken during the MTT were assayed for metabolic (glucose; nonesterified fatty acids (NEFA)) and hormonal parameters (insulin; C-peptide). On a separate occasion patients underwent a frequently sampled intravenous glucose
tolerance test (FSIVGTT). A second cannula was inserted into the antecubital fossa vein in the contralateral arm in order to give the glucose and insulin. Fasting samples were taken at -30, -15 and 0 min. Following the 0 min sample, glucose (300 mg·kg\(^{-1}\) body mass) was given intravenously over a 2 min period. Blood samples were then withdrawn over the next 20 minutes (at 1, 2, 3, 4, 5, 6, 7, 8, 10, 12, 14, 16 and 20 min). At 20 minute after the commencement of the glucose bolus, an intravenous bolus of insulin (0.05 IU·kg\(^{-1}\), Actrapid) was given and further blood samples taken over the following 3 hours (at 22, 23, 24, 25, 27, 30, 40, 50, 60, 70, 80, 90, 100, 120, 150 and 180 min).

3.2.4 Self-determination theory based instruments

Questionnaires developed to assess constructs contained within Self-determination theory (SDT) were used at baseline (Appendix 5) and post-intervention (Appendix 6). The Treatment Self-Regulation Questionnaire (TSRQ) was used to assess the degree to which a participants motivation for exercise behaviour was relatively autonomous or self-determined by measuring: autonomous motivation, controlled motivation and amotivation (Williams et al., 1996). The TSRQ is a set of questionnaires concerning why people do or would do some healthy behaviour, enter treatment for some disease, try to change an unhealthy behaviour, follow a treatment regimen, or engage in some other health-relevant behaviour. All of the questionnaires have the same purpose, to assess the degree to which a person’s motivation for a particular behaviour or set of behaviours is relatively autonomous or self-determined, but the wording varies somewhat from one version of the questionnaire to another in order to be appropriate for the particular behaviours being investigated. The TSRQ utilises a general approach to assessing autonomous self-regulation developed by Ryan and Connell (1989). The TSRQ was first used by Williams et al. (1996), and subsequently by Williams et al. (1998a) and Williams et al. (1999). The TSRQ has now been widely used in the study of behaviour change in healthcare settings. A validation article of the TSRQ was published by Levesque et al. (2007). Levesque et al. (2007) examined the validity of the TSRQ across settings and health behaviours (tobacco, diet and exercise). Data was obtained from four different sites and a total of 2731 participants completed the TSRQ. Invariance analyses supported the validity of the TSRQ across all four sites and all three health behaviours. Overall, the internal consistency of each
subscale was acceptable (most alpha values >0.73) providing further evidence of the validity of the TSRQ and its usefulness as an assessment tool across various settings and for different health behaviours.

The Psychological Needs Satisfaction in Exercise (PNSE) scale was used to assess the degree to which exercise satisfied three psychological needs – autonomy, competence, and relatedness - as outlined by SDT (Deci and Ryan, 1985, 2000). The PNSE scale was the first scale to attempt to investigate the degree to which psychological need for autonomy, competence and relatedness were fulfilled, specifically in the context of exercise. The scale consists of 18 items that are counterbalanced in terms of the number of PNSE items representing each need satisfaction dimension. Wilson et al. (2006) has provided initial construct validity evidence for scores derived from the PNSE. Participants in two studies (Study 1, n=426; Study 2, n=581) completed the PNSE along with proxy measures of need satisfaction. The results of an exploratory factor analysis in Study 1 supported the retention of a 3-factor measurement model underpinning PNSE responses. Confirmatory factor analysis conducted in Study 2 corroborated the tenability of the 3-factor measurement model in males and females and indicated partial support for invariance of PNSE scores across gender. Additionally, the scores on both the competence and relatedness subscales displayed a pattern of convergence with proxy measures. High internal consistency estimates (Cronbach alpha >0.90) were observed for all PNSE subscale scores, and participants in both studies reported high levels of need satisfaction in exercise contexts.

The Health Care Climate Questionnaire (HCCQ) - measured post-intervention only - was used to assess participants’ perception of the degree to which they experience their healthcare provider (or their physician, or their counsellor, or their healthcare program leader) to be autonomy supportive vs. controlling with respect to exercise. The questionnaire was initially validated in a study of patients visiting their primary-care physicians and was first used in a published study of obese patients participating in a weight-loss programme (Williams et al., 1996). It was subsequently used concerning diet improvement and regular exercise (Williams et al., 1998a), and adult smoking cessation (Williams et al., 1999). Alpha reliability for the 15 items has consistently been above 0.90 and a short form of the HCCQ that includes 6 of the 15 items has been shown to have an alpha reliability of 0.82.
3.2.5 Laboratory and data analysis

Plasma glucose was measured by a hexokinase assay (Diasys, Germany) using an automated analyser (Sapphire 180, Biostat, UK). Insulin and C-peptide were measured by highly specific and sensitive immuno-chemiluminometric assays (Invitron, Monmouth, UK). Glycosylated haemoglobin (HbA1c) was measured using an automated analyser (TOSOH HLC-732 G7) designed for the measurement of HbA1c under routine laboratory conditions (Terreni et al., 2003). NEFA was measured by the Wako enzymatic-colorimetric method (Alpha Labs, Eastleigh, Hants, UK) which relies upon the acylation of coenzyme A (CoA) by the fatty acids in the presence of added acyl-CoA-synthetase (ACS). Lipids were measured using a routine clinical chemistry analyser. All analyses were performed in the Diabetes Research Unit Laboratory and Biochemistry departments, Llandough Hospital, Wales, UK.

3.2.6 Modelling: β-cell function and insulin resistance

Insulin secretion rates were calculated using the Windows based Calculating Pancreatic Response application (Hovorka et al., 1998) which provides an insulin secretion model during a MTT allowing for calculation of measures of fasting (M₀) and postprandial (M₁) β-cell responsiveness. The model uses C-peptide and glucose concentrations to calculate C-peptide secretion rates, and therefore pre-hepatic insulin secretion rates (C-peptide secretion rate = pre-hepatic insulin secretion rate). Insulin resistance was calculated by homeostasis model assessment (HOMA Calculator V2.2.2) using fasting insulin and glucose concentrations (Levy et al., 1998). The acute insulin response to glucose (AIR₉) was taken to be the area under the insulin curve for the first 10 min after glucose infusion during the FSIVGTT.

3.2.7 Individual and variable response to 12-week intervention

Individual response within SCP and SEP was explored. For each individual participant, percentage change ([absolute change / baseline] x 100) for each measured variable was calculated. If percentage change was observed to be a minimum of ±10% a score of +1 or -1 was awarded indicating variable change in a beneficial (+1) or harmful (-1) direction. For example, if a participant experienced a percentage change in BMI of -12%, a score of +1 would be awarded whereas a percentage change of 12% reflecting an increase in BMI was scored -1. A percentage change of < ±10%
received a ‘0’ score. Each individual’s variable scores were then totalled to provide an individuals’ overall response score (I score). Similarly, the participant’s scores for each specific variable were totalled to provide a variables’ overall response score (V score). While it was accepted that a 10% change in one particular variable may not be equivalent to a 10% change in another variable, change of ≥ ±10% has been recognised as clinically relevant (Waters et al., 2011). The I score and V score were determined for the purpose of exploring the relative variation in response of an individual or variable respectively to SCP or SEP.

3.2.8 Statistical Analysis
Normality was determined using the Kolmogorov-Smirnov goodness-of-fit test for continuous data; all data did not meet the assumptions for parametric statistics and were expressed as median [range]. Comparison between baseline, post-intervention and 1-year follow-up data, between the two groups, was conducted using the Mann Whitney U test. Comparison between baseline, post-intervention and 1-year follow-up data, within each group, was conducted using the Wilcoxon’s signed rank test. Statistical significance was set at P<0.05. Areas under (AUC) and above (AAC) the curve were calculated using the trapezoidal method. Statistical analysis was performed using SPSS (SPSS, Incorporated, Chicago, Windows version 17.0). Participant adherence to the unsupported sessions in both the SCP and SEP was calculated by dividing the total number of self-reported exercise sessions by the number of recommended unsupported sessions (5 per week in the SCP and 2 per week in the SEP), multiplied by 100. Participant adherence (%) to the SEP was calculated by dividing the total number of supported sessions attended by the total number of sessions available, multiplied by 100.

3.3 Results
3.3.1 Participant descriptors
Descriptive characteristics for the SCP (n=9) and SEP (n=10) participants at baseline and post-intervention are shown in Table 3.2. There were no significant differences in baseline characteristics between the groups. Adherence to the unsupported exercise completed by all the participants (both groups) was monitored using self-report diaries. Adherence to the five unsupported sessions in the SCP group was reported as
69%. The adherence to the two sessions, outside the supported setting, in the SEP group was reported as 78%. The volume, mode and intensity of the self-reported exercise varied from participant to participant regardless of the group to which they were randomised. Volumes of exercise ranging from 10 min to 2 h were reported, volumes of 20-40 min of exercise were most common. Modes of exercise varied, and included swimming, walking, cycling, bowling and gardening. Intensity of exercise ranged from light to brisk walking, to cycling which left participants out of breath and sweating profusely. Adherence to the three supported 60-min sessions·week\(^{-1}\) over 12-weeks was calculated as 63% at an average intensity of 77.3% HRR.

Between-group analyses following the SCP and SEP demonstrated a significant difference for changes in LDL cholesterol only. LDL cholesterol among the SEP patients decreased significantly in comparison to the change observed following the SCP (SCP vs. SEP) (0.01 [-0.4-0.2] vs. -0.6 [-1.7-0.4] mmol·L\(^{-1}\); \(P=0.04\)). Following the 12-week SCP, within-group analyses demonstrated a significant reduction in waist circumference only (Table 3.2), whereas following the 12-week SEP significant reductions in HbA\(_1c\), waist circumference, body mass, BMI, total cholesterol and LDL cholesterol were observed (Table 3.2).

### 3.3.2 Metabolic and hormonal profiles during MTT

Participants’ responses to a standard MTT at baseline and post-intervention are shown in Figure 3.2. Comparison for fasting and postprandial glucose, insulin and NEFA measures demonstrated no significant changes following either the SCP or SEP (Table 3.3). No significant changes in β-cell responsiveness or insulin resistance (HOMA\(_{IR}\)) were observed after the SCP, however following SEP fasting β-cell (M\(_0\)) responsiveness and HOMA\(_{IR}\) significantly decreased (Table 3.3), whilst postprandial β-cell (M\(_1\)) responsiveness did not.

### 3.3.3 Measures of first phase β-cell secretion and insulin sensitivity during FSIVGTT

Following the SCP no significant changes in disposition index, glucose effectiveness (\(S_g\)) and insulin response to glucose (AIR\(_g\)) were observed. A significant increase in AIR\(_g\) was observed following the SEP.
Table 3.2 Median [range] descriptive characteristics for SCP and SEP participants at baseline (pre-) and post-intervention

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
<th>Pre</th>
<th>Post</th>
<th>Pre-Post P value</th>
<th>SCP-SEP P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body mass (kg)</td>
<td>SCP</td>
<td>102.5 [82.1-123.2]</td>
<td>101.1 [78.0-123.3]</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>91.7 [74.3-113.7]</td>
<td>87.9 [69.9-112.7]</td>
<td>0.007</td>
<td>NS</td>
</tr>
<tr>
<td>BMI (kg·m$^{-2}$)</td>
<td>SCP</td>
<td>32.3 [26.4-40.5]</td>
<td>32.0 [25.0-41.2]</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>30.0 [25.3-40.1]</td>
<td>28.7 [23.1-39.4]</td>
<td>0.006</td>
<td>NS</td>
</tr>
<tr>
<td>Waist circumference (cm)</td>
<td>SCP</td>
<td>111.1 [95.0-131.0]</td>
<td>107.6 [89.0-130.0]</td>
<td>0.05</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>101.4 [83.0-121.0]</td>
<td>97.2 [78.0-116.0]</td>
<td>0.021</td>
<td>NS</td>
</tr>
<tr>
<td>Fasting glucose (mmol·L$^{-1}$)</td>
<td>SCP</td>
<td>8.0 [6.4-11.2]</td>
<td>8.5 [5.4-13.2]</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>7.2 [5.7-9.0]</td>
<td>6.6 [5.3-7.5]</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Fasting insulin (pmol·L$^{-1}$)</td>
<td>SCP</td>
<td>139.5 [29.0-207.0]</td>
<td>123.5 [30.0-293.0]</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>100.6 [20.0-241.0]</td>
<td>81.2 [50.0-311.0]</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>HbA$_1c$ (%) (*)</td>
<td>SCP</td>
<td>6.6 [5.6-7.9]</td>
<td>6.7 [5.7-7.9]</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>6.4 [5.7-8.5]</td>
<td>6.0 [5.5-7.1]</td>
<td>0.007</td>
<td>NS</td>
</tr>
<tr>
<td>Total cholesterol (mmol·L$^{-1}$)</td>
<td>SCP</td>
<td>5.3 [3.8-7.8]</td>
<td>4.6 [3.5-5.7]</td>
<td>0.046</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>5.3 [3.8-7.8]</td>
<td>4.6 [3.5-5.7]</td>
<td>0.046</td>
<td>NS</td>
</tr>
<tr>
<td>HDL cholesterol (mmol·L$^{-1}$)</td>
<td>SCP</td>
<td>0.9 [0.7-1.2]</td>
<td>0.9 [0.8-1.3]</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>1.4 [0.9-2.5]</td>
<td>1.3 [0.6-2.4]</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>LDL cholesterol (mmol·L$^{-1}$)</td>
<td>SCP</td>
<td>2.9 [2.5-3.2]</td>
<td>2.9 [2.5-3.4]</td>
<td>NS</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>3.2 [2.2-4.6]</td>
<td>2.6 [2.0-2.9]</td>
<td>NS</td>
<td>0.04</td>
</tr>
<tr>
<td>Triglycerides (mmol·L$^{-1}$)</td>
<td>SCP</td>
<td>1.8 [0.9-4.6]</td>
<td>1.8 [0.7-3.9]</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>1.9 [1.3-3.6]</td>
<td>1.6 [0.7-2.9]</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Fasting NEFA (mmol·L$^{-1}$)</td>
<td>SCP</td>
<td>0.4 [0.2-0.6]</td>
<td>0.5 [0.3-1.4]</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

KEY: (*) Reference range <6.4%; BMI, body mass index; HDL, high-density lipoprotein; LDL, low-density lipoprotein; NEFA, nonesterified fatty acids; NS, not significant; SCP, standard care programme (n=9); SEP, supported exercise programme (n=10); Level of statistical significance shown when P<0.05. No differences between groups were found at baseline.
Table 3.3 Mean [range] derived parameters from MTT for SCP and SEP participants at baseline (pre-) and post-intervention

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
<th>Pre</th>
<th>Post</th>
<th>Pre-Post P value</th>
<th>SCP-SEP P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose Δ AUC</td>
<td>SCP</td>
<td>4.6 [-0.4-12.5]</td>
<td>3.1 [0.4-12.8]</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>0-240 min (mmol·h·L⁻¹)</td>
<td>SEP</td>
<td>4.1 [0.1-7.0]</td>
<td>4.3 [0.4-8.4]</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Insulin Δ AUC</td>
<td>SCP</td>
<td>336.8 [82-528]</td>
<td>288.9 [54-505]</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>0-30 min (pmol·h·L⁻¹)</td>
<td>SEP</td>
<td>236.5 [137-735]</td>
<td>261.5 [119-538]</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Glucose Δ AUC</td>
<td>SCP</td>
<td>1432.5 [195-1913]</td>
<td>1290.3 [290-322]</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>0-240 min (pmol·h·L⁻¹)</td>
<td>SEP</td>
<td>1017.9 [345-2005]</td>
<td>1023.8 [662-1923]</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>NEFA AAC</td>
<td>SCP</td>
<td>1.04 [0.58-1.87]</td>
<td>1.04 [0.55-1.50]</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>0-240 min (mmol·h·L⁻¹)</td>
<td>SEP</td>
<td>0.98 [0.65-1.76]</td>
<td>0.87 [0.66-1.64]</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>M₀ (x10⁹ pmol·kg⁻¹·min⁻¹)</td>
<td>SCP</td>
<td>10.9 [7.1-18.4]</td>
<td>10.8 [5.4-16.6]</td>
<td>NS</td>
<td>0.009</td>
</tr>
<tr>
<td>M₀ (x10⁹ pmol·kg⁻¹·min⁻¹)</td>
<td>SEP</td>
<td>11.5 [7.1-15.6]</td>
<td>7.0 [2.1-11.1]</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>M₁ (x10⁹ pmol·kg⁻¹·min⁻¹)</td>
<td>SCP</td>
<td>43.1 [12.6-98.1]</td>
<td>36.0 [15.6-51.8]</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>M₁ (x10⁹ pmol·kg⁻¹·min⁻¹)</td>
<td>SEP</td>
<td>41.3 [17.4-84.0]</td>
<td>39.7 [24.2-77.0]</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>HOMAIR</td>
<td>SCP</td>
<td>3.5 [1.7-7.4]</td>
<td>3.1 [1.3-6.1]</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>HOMAIR</td>
<td>SEP</td>
<td>3.0 [1.4-4.1]</td>
<td>2.1 [1.2-3.8]</td>
<td>0.049</td>
<td>NS</td>
</tr>
<tr>
<td>AIRg</td>
<td>SCP</td>
<td>35.3 [16.0-100.6]</td>
<td>31.8 [11.2-50.0]</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>AIRg</td>
<td>SEP</td>
<td>20.4 [9.8-37.2]</td>
<td>27.2 [12.1-45.0]</td>
<td>0.05</td>
<td>NS</td>
</tr>
</tbody>
</table>

KEY: AAC, area above the curve; AIRg, acute insulin response to glucose; AUC, area under the curve; HOMA, homeostasis model assessment; IR, insulin resistance; M₀, fasting β-cell function; M₁, postprandial β-cell function; NS, not significant; SCP, standard care programme (n=9); SEP, supported exercise programme (n=10). Level of statistical significance shown when P≤0.05. No differences between groups were found at baseline.
Figure 3.2 Glucose (a), Insulin (b) and NEFA (c) responses to a standard meal tolerance test (MTT) at baseline (pre-) and post-intervention.
3.3.4 Exercise tolerance test

Exercise tolerance test results for the supervised and unsupervised participants at baseline and 3 months are reported in Table 3.4. Following SCP, significant decreases in heart rate at exercise stages 1, 2, 3 and 4 was observed. No significant changes were observed during recovery phases following the SCP. Comparison of heart rate measured during the exercise tolerance test before and following the 12-week SEP, demonstrated significant decreases in heart rate at exercise stages 1, 2 and 3, and recovery phases 1 and 2.

### Table 3.4 Median [range] exercise tolerance test results (heart rate in beats·min⁻¹) for SCP and SEP participants at baseline (pre-) and post-intervention

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre</th>
<th>Post</th>
<th>Pre-Post P value</th>
<th>SCP-SEP P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exercise Stage 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCP</td>
<td>124.9 [118-135]</td>
<td>121.3 [110-136]</td>
<td>0.05</td>
<td>NS</td>
</tr>
<tr>
<td>SEP</td>
<td>130.8 [124-139]</td>
<td>127.7 [110-138]</td>
<td>0.03</td>
<td>NS</td>
</tr>
<tr>
<td><strong>Exercise Stage 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCP</td>
<td>134.2 [127-153]</td>
<td>130.9 [117-153]</td>
<td>0.05</td>
<td>NS</td>
</tr>
<tr>
<td>SEP</td>
<td>138.6 [132-146]</td>
<td>133.7 [115-142]</td>
<td>0.036</td>
<td>NS</td>
</tr>
<tr>
<td><strong>Exercise Stage 3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCP</td>
<td>145.0 [136-170]</td>
<td>137.3 [120-163]</td>
<td>0.015</td>
<td>NS</td>
</tr>
<tr>
<td>SEP</td>
<td>148.6 [139-155]</td>
<td>141.6 [122159]</td>
<td>0.021</td>
<td>NS</td>
</tr>
<tr>
<td><strong>Exercise Stage 4</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCP</td>
<td>158.4 [144-181]</td>
<td>150.9 [135-164]</td>
<td>0.011</td>
<td>NS</td>
</tr>
<tr>
<td>SEP</td>
<td>158.8 [145-169]</td>
<td>155.0 [140-172]</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td><strong>Recovery Phase 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCP</td>
<td>149.6 [120-160]</td>
<td>141.4 [120-160]</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>SEP</td>
<td>150.9 [126-161]</td>
<td>136.9 [116-164]</td>
<td>0.028</td>
<td>NS</td>
</tr>
<tr>
<td><strong>Recovery Phase 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCP</td>
<td>132.3 [110-150]</td>
<td>126.6 [108-152]</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>SEP</td>
<td>136.4 [110-153]</td>
<td>115.5 [82-146]</td>
<td>0.008</td>
<td>NS</td>
</tr>
</tbody>
</table>

KEY: NS, not significant; SCP, standard care programme (n=9); SEP, supported exercise programme (n=10). Level of statistical significance shown when P≤0.05. No differences between groups were found at baseline.

3.3.5 Self-determination theory constructs assessment outcomes

Results from questionnaires assessing constructs of the SDT are reported in Table 3.5. At baseline and post-intervention, a significant between-group (SCP-SEP) difference in perceived relatedness was observed. Post-intervention between-group comparison also demonstrated significant differences for controlled motivation and perceived autonomy support. Upon comparison of baseline and post-intervention measures related to motivation, no statistically significant within-group changes following a 12-week SCP. Following a 12-week SEP, significant changes in controlled motivation, perceived autonomy and perceived relatedness was observed.
Table 3.5 Median [range] motivation parameter results for SCP and SEP participants at baseline (pre-) and post-intervention

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
<th>Pre</th>
<th>Post</th>
<th>Pre-Post P value</th>
<th>Pre SCP-SEP P value</th>
<th>Post SCP-SEP P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autonomous Motivation</td>
<td>SCP</td>
<td>6.0 [4.0-7.0]</td>
<td>6.3 [5.5-7.0]</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>6.7 [5.7-7.0]</td>
<td>6.8 [5.8-7.0]</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Controlled Motivation</td>
<td>SCP</td>
<td>2.9 [2.2-4.0]</td>
<td>2.8 [1.5-4.8]</td>
<td>NS</td>
<td>NS</td>
<td>0.016</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>3.6 [1.3-5.8]</td>
<td>4.3 [2.0-7.0]</td>
<td>0.032</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Amotivation</td>
<td>SCP</td>
<td>2.0 [1.0-4.0]</td>
<td>2.3 [1.0-3.0]</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>2.2 [1.0-4.0]</td>
<td>1.7 [1.0-3.0]</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Perceived Competence</td>
<td>SCP</td>
<td>4.2 [1.0-6.0]</td>
<td>4.6 [1.0-6.0]</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>5.0 [4.2-6.0]</td>
<td>5.5 [4.7-6.0]</td>
<td>NS</td>
<td>NS</td>
<td>0.018</td>
</tr>
<tr>
<td>Perceived Autonomy</td>
<td>SCP</td>
<td>4.6 [1.0-6.0]</td>
<td>5.0 [4.2-6.0]</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>4.3 [1.2-6.0]</td>
<td>5.5 [4.2-6.0]</td>
<td>0.018</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Perceived Relatedness</td>
<td>SCP</td>
<td>2.5 [1.0-4.3]</td>
<td>2.6 [1.0-4.2]</td>
<td>NS</td>
<td>0.006</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>4.4 [2.0-6.0]</td>
<td>5.9 [5.7-6.0]</td>
<td>0.008</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Perceived Autonomy Support</td>
<td>SCP</td>
<td>-</td>
<td>5.9 [4.7-7.0]</td>
<td>NS</td>
<td>-</td>
<td>0.007</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>-</td>
<td>6.9 [6.2-7.0]</td>
<td>NS</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

KEY: NS, not significant; SCP, standard care programme (n=9); SEP, supported exercise programme (n=10). Psychological Needs Satisfaction in Exercise (PNSE) – Perceived Competence, Perceived Autonomy, Perceived Relatedness; Health Care Climate Questionnaire (HCCQ) – Perceived Autonomy Support; Post-intervention assessment only (-); Treatment Self-Regulation Questionnaire (TSRQ) – Autonomous Motivation, Controlled Motivation, Amotivation. Level of statistical significance shown when P≤0.05.

3.3.6 Variation in response to 12-week intervention

Individual and variable responses to the SCP and SEP are displayed in Table 3.6 and Table 3.7 respectively. The I score for each participant indicated that within each group, there was considerable variation between individuals’ response to the 12-week intervention. For instance, following the SCP, participant number one achieved an I score of -3 whilst participant number five scored 5 (Table 3.6). Similarly, among participants of the SEP, considerable variation in I score (range: -7 – 10) as well as individual compliance to the SEP (Table 3.7) was observed. Considerable variation among variables’ response to the 12-week intervention was observed in both the SCP and SEP. The SCP, appeared to have a beneficial effect on fasting insulin (V score = 4), in contrast the SCP also appeared to have a harmful effect on a number of variables including HbA1c, total cholesterol and HDL cholesterol all scoring -1. The heterogeneity among variable response following the SEP was apparent where V scores ranged from a harmful -4 for HDL cholesterol to a beneficial score of 7 for fasting β-cell function. The SEP also appeared to have a beneficial effect on total cholesterol, LDL cholesterol, triglycerides, fasting NEFA, fasting β-cell (M0), HOMAIR and AIRg where V scores ranged from 4-7. Individual participant adherence to SCP based on self-reported unsupported activity 5 sessions·week⁻¹ (Table 3.6), and the SEP in terms of supported training session attendance (3 sessions·week⁻¹), average
HRR training intensity during supported training, and self-reported unsupported activity 2 sessions·week⁻¹ (Table 3.7) are also reported.

Table 3.6 Participant and variable training response (percentage change) in relation to baseline following SCP

<table>
<thead>
<tr>
<th>Variable (%) change</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>V Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body mass</td>
<td>2.4</td>
<td>-5.0</td>
<td>-0.3</td>
<td>1.5</td>
<td>-5.6</td>
<td>-2.2</td>
<td>-5.4</td>
<td>-0.9</td>
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<td>-0.8</td>
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</tr>
<tr>
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<td>-3.0</td>
<td>-5.9</td>
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<tr>
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<td>-29.8</td>
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<td>-11.2</td>
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<td>41.5</td>
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<td>-4</td>
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<td>HbA1c</td>
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<td>12.7</td>
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<td>-11.1</td>
<td>8.3</td>
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<td>0.0</td>
<td>0.0</td>
<td>-10.0</td>
<td>-1</td>
</tr>
<tr>
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<td>Triglycerides</td>
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<td>-22.2</td>
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<td>-61.1</td>
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<td>-1</td>
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<td>Self-report</td>
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<td>93.3</td>
<td>86.7</td>
<td>78.3</td>
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</tr>
</tbody>
</table>

KEY: AIRg, acute insulin response to glucose; BMI, body mass index; HDL, high-density lipoprotein; HOMA, homeostasis model assessment; I score, individual response score; LDL, low-density lipoprotein; M₀, fasting β-cell function; M₁, postprandial β-cell function; NEFA, nonesterified fatty acids; SCP, standard care programme (n=9); V score, variable response score. Self-report, compliance with unsupported training 5 sessions·week⁻¹.

Table 3.7 Participant and variable training response (percentage change) in relation to baseline following SEP

<table>
<thead>
<tr>
<th>Variable (%) change</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>V Score</th>
</tr>
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<tbody>
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<td>-3.8</td>
<td>-4.0</td>
<td>-1.9</td>
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<td>-0.9</td>
<td>-1.8</td>
<td>-8.7</td>
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<tr>
<td>Waist circumference</td>
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<td>-4.8</td>
<td>1.1</td>
<td>-7.2</td>
<td>2.4</td>
<td>3.3</td>
<td>-6.0</td>
<td>-9.1</td>
<td>1</td>
</tr>
<tr>
<td>Fasting glucose</td>
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<td>-20.9</td>
<td>-1.4</td>
<td>7.6</td>
<td>11.9</td>
<td>-22.4</td>
<td>-6.3</td>
<td>-27.8</td>
<td>22.8</td>
<td>-28.2</td>
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<td>Fasting insulin</td>
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<td>-12.5</td>
<td>-4.0</td>
<td>-21.4</td>
<td>-10.0</td>
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<td>LDL cholesterol</td>
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<td>-37.5</td>
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<tr>
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<td>-43.8</td>
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<td>-30.8</td>
<td>-36.4</td>
<td>4</td>
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<tr>
<td>Fasting NEFA</td>
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<td>-26.2</td>
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<td>-482.5</td>
<td>45.9</td>
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<td>-53.3</td>
<td>-61.8</td>
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<td>-59.0</td>
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<td>M₁</td>
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<td>82.9</td>
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<td>-50.0</td>
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<td>-63.9</td>
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<td>2.7</td>
<td>28.6</td>
<td>-63.4</td>
<td>5</td>
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<td>86.2</td>
<td>20.9</td>
<td>91.7</td>
<td>-6.6</td>
<td>-16.6</td>
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<td>23.7</td>
<td>0.0</td>
<td>46.4</td>
<td>4</td>
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<tr>
<td>I Score</td>
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<td>8</td>
<td>7</td>
<td>6</td>
<td>-7</td>
<td>6</td>
<td>2</td>
<td>-1</td>
<td>0</td>
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</tr>
<tr>
<td>Attendance</td>
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<td>66.7</td>
<td>58.3</td>
<td>38.9</td>
<td>69.4</td>
<td>55.6</td>
<td>52.7</td>
<td>52.7</td>
<td>66.7</td>
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<tr>
<td>HRR intensity</td>
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<td>78.9</td>
<td>67.5</td>
<td>69.6</td>
<td>65.8</td>
<td>75.4</td>
<td>80.6</td>
<td>80.5</td>
<td>84.1</td>
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<tr>
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<td>45.8</td>
<td>100</td>
<td>66.7</td>
<td>75.0</td>
<td>83.3</td>
<td>79.1</td>
<td>100</td>
<td>83.3</td>
<td>58.3</td>
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</tr>
</tbody>
</table>

KEY: AIRg, acute insulin response to glucose; BMI, body mass index; HDL, high-density lipoprotein; HOMA, homeostasis model assessment; IR, insulin resistance; I score, individual response score; SEP, supported exercise programme (n=10); V score, variable response score. Attendance, attendance to supported training 3 sessions·week⁻¹; HRR, heart rate reserve training intensity during supported sessions; Self-report, compliance with unsupported training 2 sessions·week⁻¹.
3.3.7 One year follow-up

3.3.7.1 Participant descriptors

Twelve participants from both the SCP and SEP were available for follow-up at one year post-intervention. Descriptive characteristics of participants in the SCP (n=5) and SEP (n=7) at baseline, post-intervention and 1-year follow-up are shown in Table 3.8.

Adherence to the five unsupported sessions in the SCP group was reported as 72.4%. The adherence to the two sessions, outside the supported setting, in the SEP group was reported as 81.5%. Adherence to the three supported 60-min sessions·week$^{-1}$ over 12-weeks was calculated as 68.3% at an average intensity of 77.3% HRR. There were no significant differences in baseline, post-intervention and 1-year follow-up measures between the groups. Following the 12-week intervention, within-group analysis for the SCP and SEP demonstrated significant reductions in body mass, BMI and waist circumference. A further significant within-group reduction for HbA$_{1c}$ was observed following the SEP. Within-group analysis of post-intervention and 1-year follow-up measures demonstrated no significant changes among the SCP group, while a significant increase in HbA$_{1c}$ and fasting NEFA was observed in the SEP group. Within-group analysis of baseline and 1-year follow-up measures for the SCP group demonstrated significant reductions in body mass, BMI, waist circumference and fasting insulin. Within-group analysis of baseline and 1-year follow-up measures among the SEP group demonstrated significant reductions in waist circumference, fasting insulin, total cholesterol, LDL cholesterol, triglycerides, and an increase in fasting NEFA.

3.3.7.2 Metabolic and hormonal profiles during MTT

Metabolic and hormonal responses to a standard MTT at baseline, post-intervention and 1-year follow-up are shown in Table 3.9. Within group analysis of the SCP group, demonstrated insulin AUC 0-30 min decreased significantly when comparing baseline to 1-year, and post-intervention to 1-year follow-up measures. Within group analysis of the SCP group also demonstrated significant reductions in fasting β-cell (M$_0$) responsiveness and HOMA$_{IR}$ when comparing post-intervention to 1-year follow-up measures, while NEFA AAC significantly increased between baseline and 1-year follow-up measures.
### Table 3.8 Median [range] descriptive characteristics for SCP and SEP participants at baseline (pre-), post-intervention and 1-year follow-up

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
<th>Pre</th>
<th>Post</th>
<th>1 year</th>
<th>Pre-Post P value</th>
<th>Post-1 year P value</th>
<th>Pre-1 year P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body mass (kg)</td>
<td>SCP</td>
<td>95.7 [82.1-117.1]</td>
<td>92.2 [78.0-116.1]</td>
<td>90.9 [77.0-115.7]</td>
<td>0.043</td>
<td>NS</td>
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</tr>
<tr>
<td></td>
<td>SEP</td>
<td>92.0 [74.3-111.4]</td>
<td>87.5 [72.9-106.3]</td>
<td>89.2 [74.5-109.6]</td>
<td>0.028</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>BMI (kg·m⁻²)</td>
<td>SCP</td>
<td>30.3 [26.4-38.9]</td>
<td>29.3 [25.0-38.6]</td>
<td>29.0 [23.8-38.7]</td>
<td>0.042</td>
<td>NS</td>
<td>0.043</td>
</tr>
<tr>
<td>Waist circumference (cm)</td>
<td>SCP</td>
<td>106.3 [95.0-131.0]</td>
<td>101.1 [89.0-130.0]</td>
<td>100.4 [88.0-130.0]</td>
<td>0.042</td>
<td>NS</td>
<td>0.043</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>104.8 [93.0-121.0]</td>
<td>99.8 [83.0-116.0]</td>
<td>99.3 [84.5-117.5]</td>
<td>0.046</td>
<td>NS</td>
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<tr>
<td>Fasting glucose (mmol·L⁻¹)</td>
<td>SCP</td>
<td>7.8 [6.4-9.0]</td>
<td>7.6 [6.1-9.6]</td>
<td>7.4 [5.7-9.4]</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>7.5 [6.7-9.0]</td>
<td>6.6 [5.3-7.5]</td>
<td>6.9 [5.7-8.6]</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Fasting insulin (pmol·L⁻¹)</td>
<td>SCP</td>
<td>112.4 [29.0-207.0]</td>
<td>118.0 [3.0-293.0]</td>
<td>86.2 [23.0-169.0]</td>
<td>NS</td>
<td>NS</td>
<td>0.043</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>100.7 [28.0-167.0]</td>
<td>95.3 [50.0-131.0]</td>
<td>91.7 [40.0-155.0]</td>
<td>NS</td>
<td>NS</td>
<td>0.045</td>
</tr>
<tr>
<td>HbA₁c (%) (*)</td>
<td>SCP</td>
<td>6.4 [6.1-6.5]</td>
<td>5.9 [5.7-6.1]</td>
<td>6.5 [5.9-7.4]</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>6.5 [5.7-8.5]</td>
<td>6.0 [5.5-7.1]</td>
<td>6.4 [5.7-8.2]</td>
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<td>0.034</td>
<td>NS</td>
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<tr>
<td>Total cholesterol (mmol·L⁻¹)</td>
<td>SCP</td>
<td>4.6 [4.5-4.6]</td>
<td>4.2 [4.1-4.3]</td>
<td>4.2 [4.1-4.2]</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>5.1 [4.8-5.4]</td>
<td>4.4 [3.5-5.7]</td>
<td>3.8 [2.7-4.8]</td>
<td>NS</td>
<td>NS</td>
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</tr>
<tr>
<td>HDL cholesterol (mmol·L⁻¹)</td>
<td>SCP</td>
<td>1.1 [0.9-1.2]</td>
<td>1.1 [0.8-1.3]</td>
<td>1.3 [1.0-1.6]</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>1.4 [0.9-2.5]</td>
<td>1.3 [0.6-2.4]</td>
<td>1.2 [0.8-1.8]</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>LDL cholesterol (mmol·L⁻¹)</td>
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<td>2.8 [2.7-2.8]</td>
<td>2.5 [2.1-2.8]</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
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<td>2.5 [2.0-2.9]</td>
<td>2.0 [1.4-2.9]</td>
<td>NS</td>
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</tr>
<tr>
<td>Triglycerides (mmol·L⁻¹)</td>
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<td>0.9 [0.9-1.0]</td>
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<td>NS</td>
<td>NS</td>
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</tr>
<tr>
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<td>NS</td>
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</tr>
<tr>
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<td>0.6 [0.3-1.4]</td>
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<td>NS</td>
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</tr>
<tr>
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<td>0.3 [0.3-0.5]</td>
<td>0.7 [0.3-1.0]</td>
<td>NS</td>
<td>NS</td>
<td>0.028</td>
</tr>
</tbody>
</table>

**KEY:** (*) Reference range <6.4%; BMI, body mass index; HDL, high-density lipoprotein; LDL, low-density lipoprotein; NEFA, nonesterified fatty acids; NS, not significant; SCP, standard care programme (n=5); SEP, supported exercise programme (n=7); Level of statistical significance shown when P≤0.05. No differences between groups were found at baseline.
Table 3.9 Median [range] derived parameters from MTT for SCP and SEP participants at baseline (pre-), post-intervention and 1-year

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
<th>Pre</th>
<th>Post</th>
<th>1 year</th>
<th>Pre-Post P value</th>
<th>Post-1 year P value</th>
<th>Pre-1 year P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose Δ AUC 0-240 min (mmol·h·L⁻¹)</td>
<td>SCP</td>
<td>5.1 [0.4-12.5]</td>
<td>4.6 [0.4-12.8]</td>
<td>5.6 [0.9-12.8]</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>3.9 [0.1-7.0]</td>
<td>3.0 [0.4-6.6]</td>
<td>2.1 [0.6-6.3]</td>
<td>0.042</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Insulin Δ AUC 0-30 min (pmol·h·L⁻¹)</td>
<td>SCP</td>
<td>261.4 [82.0-491.0]</td>
<td>267.3 [54.0-505.0]</td>
<td>29.4 [4.4-69.8]</td>
<td>NS</td>
<td>0.043</td>
<td>0.043</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>321.2 [137.0-735.0]</td>
<td>331.4 [190.0-538.0]</td>
<td>54.9 [0.3-59.9]</td>
<td>NS</td>
<td>0.018</td>
<td>0.018</td>
</tr>
<tr>
<td>Insulin Δ AUC 0-240 min (pmol·h·L⁻¹)</td>
<td>SCP</td>
<td>427.2 [343.0-1791.0]</td>
<td>1280.7 [290.0-3226.0]</td>
<td>79.2 [327.2-1482.3]</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>1137.8 [345.0-2005.0]</td>
<td>1084.6 [662.0-1551.0]</td>
<td>1166.4 [756.0-1713.5]</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>NEFA AAC 0-240 min (mmol·h·L⁻¹)</td>
<td>SCP</td>
<td>1.3 [0.7-1.9]</td>
<td>1.0 [0.6-1.5]</td>
<td>1.7 [1.2-1.9]</td>
<td>NS</td>
<td>NS</td>
<td>0.043</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>1.1 [0.7-1.7]</td>
<td>1.0 [0.7-1.6]</td>
<td>1.9 [0.9-2.9]</td>
<td>NS</td>
<td>0.028</td>
<td>0.028</td>
</tr>
<tr>
<td>M₀ (x10⁹ pmol·kg⁻¹·min⁻¹)</td>
<td>SCP</td>
<td>9.5 [7.1-12.6]</td>
<td>10.2 [5.4-16.6]</td>
<td>7.3 [4.9-9.4]</td>
<td>NS</td>
<td>0.043</td>
<td>NS</td>
</tr>
<tr>
<td>M₁ (x10⁹ pmol·kg⁻¹·min⁻¹)</td>
<td>SCP</td>
<td>32.2 [19.6-39.8]</td>
<td>32.6 [15.6-40.3]</td>
<td>33.0 [8.2-67.7]</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>40.1 [17.4-69.4]</td>
<td>35.4 [24.2-53.5]</td>
<td>43.6 [26.8-58.8]</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>HOMAIR</td>
<td>SCP</td>
<td>2.9 [1.7-4.5]</td>
<td>3.0 [1.3-6.1]</td>
<td>2.1 [0.5-4.2]</td>
<td>NS</td>
<td>0.043</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>3.2 [1.8-4.1]</td>
<td>2.1 [1.3-3.8]</td>
<td>2.1 [0.9-3.6]</td>
<td>0.018</td>
<td>NS</td>
<td>0.018</td>
</tr>
<tr>
<td>AIRg</td>
<td>SCP</td>
<td>25.4 [17.9-34.0]</td>
<td>27.0 [11.2-49.6]</td>
<td>18.2 [8.8-37.4]</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>22.4 [9.8-37.2]</td>
<td>27.2 [12.2-45.0]</td>
<td>19.5 [9.5-34.2]</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

KEY: AAC, area above the curve; AIRg, acute insulin response to glucose; AUC, area under the curve; HOMA, homeostasis model assessment; IR, insulin resistance; M₀, fasting β-cell function; M₁, postprandial β-cell function; NS, not significant; SCP, standard care programme (n=5); SEP, supported exercise programme (n=7). Level of statistical significance shown when P≤0.05. No differences between groups were found at baseline.
Within group analysis of the SEP group, demonstrated insulin AUC 0-30 min decreased significantly when comparing baseline to 1-year, and post-intervention to 1-year follow-up measures. Within group analysis of the SCP group also demonstrated significant reductions in fasting β-cell (M₀) responsiveness when comparing baseline to post-intervention measures, HOMA_{IR} when comparing baseline to post-intervention and baseline to 1-year follow-up measures, and a significant increase in NEFA AAC between baseline and 1-year, and post-intervention and 1-year follow-up measures.

3.3.7.3 Measures of first phase β-cell secretion and insulin sensitivity during FSIVGTT
No significant changes in disposition index, glucose effectiveness (Sₑ) and acute insulin response to glucose (AIRg) were observed for either the SCP or SEP groups.

3.4 Discussion
Newly diagnosed T2DM patients often receive only general advice in the first three months after initial diagnosis as part of standard treatment despite limited research investigating the benefits of such advice. The primary objective of the present study was to investigate the effectiveness of a 12-week unsupported exercise programme (akin to standard care) (SCP) and a 12-week supported exercise programme (SEP) on glycaemic control, β-cell responsiveness, insulin resistance and lipid profiles during the 3-month period following initial diagnosis in T2DM patients.

3.4.1 12-week intervention
To begin, from a group thirty potential participants nine were excluded from the study due to cardiac anomalies observed during the exercise tolerance test. This contributed to the small sample size of the present study, but also emphasised the risks associated with exercise for this population and stresses the importance of effective early treatment for newly diagnosed T2DM patients.

Between-group analysis of changes observed following the SCP and SEP demonstrated a significant change in LDL cholesterol only. Clinically relevant changes were observed when comparing the SCP to the SEP for a number of variables. For example, an overall difference of -0.5% for HbA₁c (SCP vs. SEP) (+0.1 vs. -0.4%) was shown, where HbA₁c was reduced in nine out of ten of the SEP
participants in comparison to a reduction in only three out of nine participants from the SCP group. The SEP also showed an overall difference of -1.0 mmol·L⁻¹ for fasting plasma glucose (+0.5 vs. -0.6 mmol·L⁻¹), again in favour of SEP. The clinical significance of this finding can be gauged from the UKPDS (1998) where HbA₁c decreased by 0.6% among patients’ randomised to intensive glycaemic control with metformin. Such a reduction was associated with reduced microvascular complications (UKPDS, 1998). Significant reductions in body mass (91.7 vs. 87.9 kg) were also observed following the supported exercise programme. Reductions in HbA₁c (1.8%) and body mass (1.0 kg) have also been found by Goldhaber-Fiebert et al. (2003) following a 12-week tri-weekly walking group (60 min·session⁻¹) study. Dunstan et al. (2002) found significant decreases in HbA₁c in a resistance training plus weight loss group when compared to weight loss only group at 3 months (0.6 vs. 0.07%) suggesting exercise is an important component of improved glycaemic control. A meta-analysis of exercise interventions by Boulé et al. (2001) concluded improved HbA₁c were mediated by exercise and not by changes in body mass. The analysis found exercise interventions which averaged 3 sessions per week for 16 weeks at intensities of 50-75% VO₂max reduced HbA₁c by approximately 0.66%. This finding compares well with the outcome of the present study where supported exercise group patients exercised at an average intensity of 77.3% HRR 3 times per week for only 12 weeks. Similar within-group findings to the present study are provided by Alam et al. (2004). HbA₁c (8.7 vs. 7.7%), BMI (30.7 vs. 28.7 kg·m⁻²), NEFAs (0.9 vs.0.5 mmol·L⁻¹) and insulin resistance indicated by HOMAIR (8.2 vs. 5.2) improved among patients (diagnosed for a minimum of 8 years) participating in a supervised exercise intervention consisting of 4 sessions per week, at 70% VO₂max for 6 months. No significant changes were observed within the unsupervised group.

One of the first physiological defects in the development of T2DM is a decrease or loss in the first phase insulin response to intravenous glucose (Owens et al., 1996). In the present study overall postprandial β-cell response did not change following SCP or SEP, however an improvement in early phase postprandial insulin response was seen as demonstrated by a significant improvement in AIRg (20.4 vs. 27.2) in conjunction with significant improvements in HbA₁c - which reflects both fasting and postprandial glucose levels, - among SEP participants. Significant improvement in AIRg, although marginal, in conjunction with significant improvements in HbA₁c
levels may also suggest a slowing of the natural progression of the disease (Weyer et al., 1999) among newly diagnosed patients in the SEP. The improved early phase insulin release may be attributable to the significantly reduced insulin resistance (3.0 vs. 2.1) also observed within the supported exercise group, which in turn could have a sparing effect on the function of the β-cell. Reduced insulin secretion indicated by a significant decrease in fasting β-cell responsiveness (11.5 x10^{-9} vs. 7.0 x10^{-9} pmol·kg^{-1}·min^{-1}) was also observed among patients in the SEP. Using disposition index (DI) as a measure of β-cell function Slentz et al. (2009) found moderate-intensity exercise training improved DI significantly more so than vigorous-intensity exercise in sedentary overweight, moderately dyslipidaemic participants. While moderate-intensity exercise was also found to improve insulin sensitivity, there was no compensatory decrease in AIR_g (Slentz et al., 2009). AIR_g has been found to decrease progressively across levels of glucose tolerance (from normal to impaired to diabetic) (Hong et al., 2007), and ongoing loss of β-cell function may limit the ability of exercise interventions to aid glycaemic control in T2DM patients over the long term.

Within-group analyses following the SEP demonstrated an improved lipid profile as indicated by significant reductions of total cholesterol (5.3 vs. 4.6 mmol·L^{-1}) and LDL cholesterol levels (3.2 vs. 2.6 mmol·L^{-1}). In T2DM patients, high levels of visceral adiposity have been found to lead to elevated plasma NEFA levels, increased fatty acid oxidation and decreased basal glucose utilisation and oxidation (Cusi et al., 2007). Evidence also supports the association of dyslipidaemia and insulin resistance with increased visceral adiposity (Després et al., 1990). Schenk and Horowitz (2007) have observed that acute exercise increases triglyceride synthesis in skeletal muscle and prevents fatty acid induced insulin resistance. Exercise undertaken within SEP may have resulted in improved fat oxidation leading to a reduction in lipotoxicity in skeletal muscle, liver and/or the pancreas (Slentz et al., 2009). Improved fat oxidation when viewed in conjunction with decreased waist circumference (101.4 vs. 97.2 cm), indicative of reduced visceral adipose tissue, may help explain the improvement in lipid profile and reduction in insulin resistance observed following the SEP. Improvements in lipid profile and insulin resistance were not observed in SCP group despite a significant reduction in the groups waist circumference (111.1 vs. 107.6 cm),
suggesting supported exercise may play an important role beyond reduction in visceral adipose tissue alone.

### 3.4.2 Exercise tolerance

Reduction in heart rate during exercise stages (SCP, 1,2,3,4; SEP, 1,2,3) and recovery phases (SEP, 1, 2) observed in the present study may be indicative of improved cardiorespiratory fitness and improved heart rate recovery, an independent predictor of cardiovascular disease (CVD) and all-cause mortality among diabetic men (Cheng et al., 2003). The significant reductions in heart rate during the exercise tolerance test at stages 1-3 observed following both SCP and SEP, and the significantly faster rates of heart rate recovery observed among SEP participants, suggest higher rates of fitness most likely derived from increased physical activity levels during the 12-week intervention. In the present study, the increase in regular exercise experienced by those on the SEP may help explain improved heart rate recovery (Darr et al., 1988), as well as the observed improvement in markers of glucose metabolism such as HbA1c (Giacca et al., 1998). Further, in the present study an improvement in heart rate recovery and fasting plasma glucose concentration was observed following the SEP, and it has been previously reported that fasting plasma glucose is strongly and independently associated with abnormal heart rate recovery (Panzer et al., 2002).

### 3.4.3 Outcomes from self-determination theory constructs

Analysis of baseline and post-intervention measures was performed following randomisation and intervention completion. No significant within-group changes were observed following the SCP. Significant between-group (SCP vs. SEP) differences in perceived relatedness at baseline (2.5 vs. 4.4) and post-intervention (2.6 vs. 5.9) was observed. Deci and Ryan (2000) suggest that perceived relatedness instigates the internalisation process within domains such as exercise. An increase in perceived relatedness or “feeling related and connected to the people [I] exercise with” from baseline to post-intervention measures following SEP (4.4 vs. 5.9) maybe explained by the nature of the programme, which included, peer support afforded to one another by participants. However, it is unclear why the SCP and SEP differed significantly for this measure at baseline. A possible explanation would be participants in the SEP were generally more physically active at baseline than those in the SCP which may
have contributed to motivation to volunteer for the present study. Previous exercise-based studies (Wilson et al., 2002; 2003) suggest that participants who are physically active have already internalised exercise to form an integral component of their self-system, in which instance an individual would likely report a higher score for perceived relatedness. Significant between-group differences at post-intervention (2.8 vs. 4.3) and within-group change following SEP (3.6 vs. 4.3) for controlled motivation were also observed. An explanation for significant changes in controlled motivation, i.e. introjected or external reasons, observed following between-group analysis at post-intervention and within-group analysis following SEP group may include peer support and instructor guidance afforded by the supported exercise programme.

Following the SEP, there were also significant changes in perceived autonomy (4.3 vs. 5.5) and perceived relatedness (4.4 vs. 5.9). Perceived autonomy or “feeling autonomous and choice in the exercise I do” were also found to be increased following the SEP. A possible explanation lies in Markland’s (1999) suggestion that perceived autonomy and intrinsic motivation contribute to each other in the context of exercise participation. Buckworth et al. (2007) provide further support with the notion that, people in physical activity classes have more strongly developed intrinsic motivation than those receiving only verbal information. Perceived autonomy support, defined as the belief that significant others such as teachers, coaches, parents and friends support self-initiation, opportunities for choice, independent problem-solving and involvement in decision making as well as acknowledging feelings and avoiding making pressuring demands (Mageau and Vallerand, 2003) assessed following intervention completion were also found to be significantly different between the SCP and SEP (5.9 vs. 6.9). The nature of the SEP likely explains the autonomy related observations as it is expected that individuals who deem significant others to display these autonomy-supportive characteristics are more likely to approach tasks with an autonomous, self-determined motivational style (Black and Deci, 2000). Research suggests that perceived autonomy support is an important influence on autonomous forms of motivation and behaviours in a social context such as education (Reeve, 2002) and exercise (Hagger et al., 2003). Of interest, Sheldon et al. (2001) contend that greater perceptions of autonomy, competence, and relatedness in exercise is
associated with more positive and less negative affect typically experienced during exercise participation which may lend further support to use of supported exercise programmes such as that of the present study.

3.4.4 Variation in response to 12-week intervention

The heterogeneity of response among participants of an intervention is not a new phenomenon, but most studies evaluating the efficacy of exercise tend to report the mean data and overlook the inter-individual variability (King et al., 2008). In the present study variation in participant response to the 12-week intervention was evident within both the SCP and SEP groups (Tables 3.6 and 3.7). Within the SCP group, participant number one achieved an I score of -3 whilst participant number five achieved an I score of 5. In the SEP, participant number two achieved an I score of 8 whereas participant number five achieved an I score of -7. In part, variation in response among participants of the SCP and SEP groups may be accounted for by compliance or adherence (Manninen et al., 1998; Laurance et al., 2003). Participants one and five of the SCP group had similar adherence to the programme, 85% and 90% respectively, although it should be noted that adherence for this group was assessed via self-report methods therefore limiting the conclusions which can be drawn. Whereas attendance to the supported exercise sessions in the SEP for participants two (83.3%) and five (38.9%) would appear to provide a likely explanation for their varying I scores.

However, if compliance is accounted for and members of an exercising group are exposed to the same volume of physical activity, adjusted for their own tolerance level, response to the exercise stimuli may vary from one individual to another (Bouchard and Rankinen, 2001). In the SEP, participants one and four of the SEP achieved the same I score (6), despite participant number four adhering to less supported sessions (58.3% vs. 80.5%), lower exercise training intensity (67.5 % vs. 86.5%) and reporting less unsupported activity (66.7% vs. 87.3%) in comparison to participant one. Variation in individual response is further emphasised by comparing participant number ten (I score = 10) to participant number one. Although comparable for exercise training intensity, participant ten again demonstrated lower levels of adherence to both supported (66.7%) and unsupported activity (58.3%) when
compared to participant number one. While self-reported adherence to unsupported activity should be viewed with caution a plausible explanation for this observation is provided by Booth and Laye (2010), who suggest individuals can be described as expressing ‘high sensitivity’ and ‘low sensitivity’ in response to a given stimuli. It is possible that despite apparently undertaking a lower exercise workload, participants four and ten of the SEP group, had higher sensitivity to the exercise stimuli than participant number one.

Adaptations to exercise training such as heart rate at low work loads, improvements in blood pressure and insulin sensitivity in diabetic patients have also been found to have variable magnitudes in response to exercise training (Bouchard and Rankinen, 2001; Fritz et al., 2006). Booth and Laye (2010) suggest that response to exercise within a given organ is polygenic and affects multiple organ systems, thus it is likely that exercise will have an effect on some variables while not affecting others. The heterogeneity of variable response in the present study, displayed in Table 3.7 as V score, may support Booth and Laye. It would appear that variables which are often the focus of diabetes management such as HbA1c and body composition variables are less responsive than lipids following 12-week SEP. For example, V scores for total cholesterol, LDL cholesterol, triglycerides and fasting NEFA were either 4 or 5, compared to V scores of 1 or 2 for HbA1c, body mass, BMI and waist circumference. The clinical relevance of this observation may be supported by Vollaard et al. (2009) who demonstrated that a group of participants who did not increase VO2max in response to aerobic exercise did show improvements in oxidative enzyme activities in muscle. Unfortunately, failure to improve a desirable phenotype or observable trait at group or individual level such as VO2max (in the case of Vollaard et al., 2009) or HbA1c within diabetes interventions is often concluded as the ineffectiveness of exercise. With regard to lipid sensitivity attention should also be drawn to the apparent effect of SEP on HDL cholesterol. Although no significant change was observed within a group context, upon viewing individual response HDL cholesterol achieved a V score of -5. The harmful effect of exercise on HDL cholesterol, possibly due to increased fat oxidation, is not widely supported, however, Kelley and Kelley (2007) suggest reductions in HDL cholesterol levels may be detrimental and associated with increased risk of coronary heart disease (Kelley and Kelley, 2007).
To conclude, as some variables appear more responsive to exercise stimuli than others, it is reasonable to suggest that intervention effectiveness should not be gauged on specific or individual variables alone. Instead programmes modelled on individualised interventions which provide greater consideration of heterogeneous responses at both individual and parameter levels should be promoted and further researched as advocated by Kraushaar and Krämer (2009).

3.4.5 One year follow-up

Twelve participants (SCP, n=5; SEP, n=7) were followed up one-year after completing the 12-week intervention. Between-group analysis at baseline, post-intervention and 1-year follow-up demonstrated no significant differences. Within-group analysis of baseline to post-intervention measures demonstrated significant reductions in body mass (95.7 vs. 92.2 kg), BMI (30.3 vs. 29.3 kg·m$^{-2}$) and waist circumference (106.3 vs.101.1 cm) following the SCP. Within-group analysis of post-intervention to 1-year follow-up measures demonstrated significant reductions within the SCP group for fasting β-cell responsiveness ($10.2 \times 10^{-9}$ vs. $7.3 \times 10^{-9}$ pmol·kg$^{-1}$·min$^{-1}$) and HOMA$_{IR}$ (3.0 vs. 2.1). Comparison of baseline and 1-year follow-up measures within the SCP group demonstrated significant and continued reduction in body mass (95.7 vs. 90.9 kg), BMI (30.3 vs. 29.0 kg·m$^{-2}$) and waist circumference (106.3 vs. 100.4 cm), significant reduction in fasting insulin (112.4 vs. 86.2 pmol·L$^{-1}$) and a significant increase in NEFA AAC (1.3 vs. 1.7 mmol·h$^{-1}$·L$^{-1}$).

Baseline to post-intervention within-group analysis following the SEP demonstrated significant reductions in body mass (92.0 vs. 87.5 kg), BMI (30.6 vs. 29.2 kg·m$^{-2}$), waist circumference (104.8 vs. 99.8 cm), HbA$_{1c}$ (6.5 vs. 6.0%), glucose AUC 0-240 min (3.9 vs. 2.1 mmol·h$^{-1}$·L$^{-1}$), fasting β-cell responsiveness ($11.5 \times 10^{-9}$ vs. $7.0 \times 10^{-9}$ pmol·kg$^{-1}$·min$^{-1}$) and HOMA$_{IR}$ (3.2 vs. 2.1). Within-group analysis of post-intervention to 1-year measures for the SEP group demonstrated significant increases in HbA$_{1c}$ (6.0 vs. 6.4%), fasting NEFA (0.3 vs. 0.7 mmol·L$^{-1}$) and NEFA AAC (1.0 vs. 1.9 mmol·h$^{-1}$·L$^{-1}$). Comparison of baseline and 1-year follow-up measures within the SEP group demonstrated significant and continued reduction in waist circumference (104.8 vs. 99.3 cm), significant reduction in fasting
insulin (100.7 vs. 91.7 pmol·L\(^{-1}\)), a significant increase in NEFA AAC (1.1 vs. 1.9 mmol·h\(^{-1}\)·L\(^{-1}\)), continued reduction in HOMA\(_{IR}\) (3.2 vs. 2.1), and significant reductions in total cholesterol (5.1 vs. 3.8 mmol·L\(^{-1}\)), LDL cholesterol (2.9 vs. 2.0 mmol·L\(^{-1}\)) and triglycerides (1.7 vs. 1.3 mmol·L\(^{-1}\)).

One year follow-up of participants of the 12-week intervention highlights a number of interesting issues for discussion. The reduction in sample size attributed to ‘loss to follow-up’ as defined in the Consort guidelines revealed significant changes among some variables which were less obvious upon initial baseline to post-intervention analysis. This was particularly evident within the SCP group. The non-deliberate removal of participants at 1-year follow-up further suggests that the magnitude of response to intervention varied from individual to individual within each group, and within each variable. This lends support to further investigating the sensitivity of individuals and different variables to exercise stimuli within the diabetes population particular in the context of long-term management of the condition through physical activity. Significant reductions in some variables such as HbA\(_1c\) following the 12-week SEP were lost with a return to near baseline value. However, reductions in insulin resistance (HOMA\(_{IR}\)) were maintained and encouragingly a reduction in fasting insulin as well as improved lipid profile was achieved. While previous research (Dunstan et al., 2006) has demonstrated that improvements in glycaemic control achieved following a supervised exercise intervention could not be sustained in an unsupported setting where exercise levels fell, the improvements in insulin resistance and lipid profile achieved up to one-year after programme completion in the current study suggests merit in such a supported programme. It is also plausible that participation in the intervention, even among control participants (SCP), initiated a reactionary response which had positive implications on exercise behaviour during the 12-week intervention and in the months that followed. Lastly, all twelve participants followed up at 1-year, representing 63% of the initial intervention cohort, continued to manage their diabetes without the need for pharmaceutical intervention, which given the progressive nature of T2DM lends further support to the importance of interventions aimed at increasing exercise and physical activity levels among newly diagnosed T2DM patients.
3.4.6 Limitations

There are a number of limitations which should be considered when interpreting the findings of this study. The small sample size in the present study, limits the generalisability of the findings to the wider T2DM population. It is presumed that with larger sample size ‘between-group’ effects are more likely to be apparent. The present study also emphasises the difficulty in recruiting eligible participants for exercise interventions due in part to exclusion criteria as well as shortage of willing volunteers within this population, while the present cohort may represent a more motivated volunteer sample. Participants were recruited to the present study within 3 months of being diagnosed, baseline HbA1c was comparable and all patients were treatment naïve. It is however acknowledged that rate of β-cell decline and disease progression may have varied between individuals as T2DM patients can remain asymptomatic for as long as 4-7 years before clinical diagnosis (Harris et al., 1992). This should be considered when applying the findings of this study to individuals with longer-term diabetes or those who demonstrate advanced disease progression. Self-report methods were used to assess adherence to unsupported activity among participants of both the SCP and SEP. Limitations of self-report methods, including social desirability bias which can lead to an over reporting of physical activity levels, dictates that observations surrounding adherence and related outcomes such as individual response to exercise, should be considered with caution. This study aimed to simulate a ‘real-world’ scenario where the SCP was as close to ‘standard’ treatment as possible which included advice in accordance with the recommended physical activity guidelines only. Although participants in both groups were encouraged to complete exercise diaries detailing their activity behaviour over the 12-week intervention, completion of exercise diaries was poorly adhered to by most participants. It is accepted that participants failed to understand the importance their exercise diaries and while this is a limitation of the present study it is also indicative of the inherent problem associated with self-report methods. The use of baseline HRR and provision of advice about intensity targets (utilising heart rate monitors for both intensity compliance and recording exercise durations) for the SCP group in particular may have helped to provide more objective measures of unsupported activity adherence. Use of HOMAIR particularly in small studies among patients with established diabetes to assess insulin resistance has been criticised since it only utilises fasting measurements of glucose and insulin and maybe considered to be
predominantly an index of hepatic insulin resistance. A more appropriate method may have been to use the Matsuda index of insulin sensitivity (Matsuda and DeFronzo, 1999) which would provide a more complete assessment of total body insulin sensitivity. Although some caution should be taken regarding HOMA\textsubscript{IR}, like HOMA\textsubscript{IR}\textsuperscript{IR} the Matsuda index also contains fasting values in its calculation and both methods have been shown to correlate well with minimal model and euglycemic clamp assessments of insulin sensitivity (Wallace et al., 2004). No formal assessment of cardiorespiratory fitness, at baseline and post-intervention, is a limitation of the study. The modified Bruce protocol with 12 lead ECG was used to determine submaximal exercise capacity (submaximal heart rate) and to identify possible cardiac abnormalities including, angina, ST segment depression and coronary artery blockage during screening of potential participants for the study. Heart rate values from the modified Bruce protocol have been included however, more robust assessment of cardiorespiratory fitness and post-intervention repetition of this index would have been useful in determining the mechanism by which the SEP had its effect. The mechanism by which improved metabolic health has occurred in the present study is unclear. A larger study with more detailed assessment of metabolic function (measuring parameters such as endothelial function, substrate utilisation/metabolic rate, and markers of lipid metabolism) would be of benefit in considering potential mechanisms by which exercise might have led to the findings in the present study. Lastly, the present study did not control for diet which potentially limits the conclusions that can be drawn with regard to the effects of exercise among newly diagnosed T2DM patients.

3.4.7 Conclusion

The present study sought to investigate the effect of standard care (SCP) in comparison to support for exercise (SEP) among the two groups of newly diagnosed T2DM patients. The study suggests SEP increases exercise levels by helping newly diagnosed T2DM patients to achieve moderate-high intensity physical activity 3-5 days·week\textsuperscript{-1} through peer support and encouragement as well as provision of a safe exercise environment, individualised exercise prescription, heart rate monitoring, and supervision. Despite the study being underpowered the study provides evidence to suggest increased regular physical activity and subsequent increased exercise capacity afforded by a SEP significantly improves glycaemic control, through enhanced β-cell
function associated with decreased insulin resistance and improved lipid profile. While 12-weeks of standard care (SCP) did not appear to provide any significant benefits to patients in terms of glycaemic control, β-cell function, insulin resistance or lipid profile. A SEP appeared to have a positive effect on measures of motivation for exercise related to self-determination theory, whilst SCP had no significant impact. Investigation of intervention effects at an individual level suggests that the impact of both SCP and SEP is likely to vary between participants and thus phenotype, individualised exercise prescription and magnitude of variable response, merits further investigation. Despite loss to dropout, follow-up of a subset of participants at 1-year post-intervention suggests the effects of both SCP and SEP may impact beyond the initial 12-week intervention. A number of study limitations are acknowledged and future studies should strive to more clearly demonstrate the effects of ‘support’ through more accurate measurement of exercise duration, exercise intensity, and exercise frequency among both groups (standard care and supported) as well as formal measurement of cardiorespiratory fitness and other metabolic parameters at baseline and post-intervention which may help to explain the mechanisms by which supported exercise can provide benefits to the patient. Although the small sample size of the present study limits the generalisability of the findings it is important to acknowledge that despite being underpowered, statistically significant changes were observed. Furthermore, future studies should acknowledge the difficulties encountered in the present study in relation to participant recruitment and retention, which was made more difficult by a number of factors which included the necessity for patients to be treatment naïve, newly diagnosed with T2DM within the preceeding 3 months, and required a high level of volunteer commitment for the invasive and time demanding nature of the study tests at baseline and follow-up (i.e. MTT, IVGTT and exercise ECG) and the intensive 12-week intervention. While these factors restricted the number of participants recruited, they also represent vital aspects of the study design which contributed to the novelty and strength of the present study. Whilst the benefits of exercise compared to no exercise in diabetes patients has been recognised (Dunstan et al., 2002; Goldhaber-Fiebert et al., 2003; Alam et al., 2004) further research investigating the effects of unsupported and supported exercise programmes is needed to enable healthcare professionals to provide newly diagnosed T2DM patients with more comprehensive support aimed at increasing exercise and physical activity levels.
Chapter 4

Physical activity within self-management behaviour in type 2 diabetes mellitus
4.1 Introduction

The following chapter describes an exploratory study investigating physical activity and self-management behaviour among a population of type 2 diabetes mellitus (T2DM) patients detailing the methods used, study results, followed by a discussion of the findings, and their implications for future research and practice.

4.1.1 Overview

Studies of people with T2DM have shown that the onset of diabetes related complications can be prevented and or delayed through management of glycaemia (defined as ‘good glycaemic control’ of HbA1c ≤7.0%, ADA, Standards of Medical Care in Diabetes - 2010) and cardiovascular risk factors (Knight et al., 2005). Glasgow et al. (2001) observed that self-management is largely dictated by the patient; wherein, the patient decides which diabetes self-management strategies to practice and to what level, and it is ultimately the patient who experiences the results of those self-care actions. Key to achieving good glycaemic control is a patient’s motivation to perform self-management behaviours such as monitoring diet, performing physical activity, taking medication and testing blood glucose levels. However, these necessary behaviours all vie with one another as well as compete with life’s other motivations, behaviours and demands (Collins et al., 2009). Kavookjian et al. (2007) suggests of the self-management behaviours affecting glycaemic control and prevention of diabetes complications, the lifestyle behaviour of physical activity remains the most problematic. Plotnikoff et al. (2011a) suggests up to 70% of patients with T2DM do not achieve the recommended guidelines for physical activity. Jones et al. (2003) suggest the problem of physical inactivity among this population, may be due to the complexity of achieving and maintaining physical activity behaviour and managing change on multiple self-management behaviours at the same time. Similarly, Kavookjian et al. (2005) suggests the difficulty may be explained by the decision-making strategies a patient adopts in managing their diabetes.

The benefits of physical activity for those with T2DM are widely recognised (Albright et al., 2000; Boulé et al., 2003; Sigal et al., 2004; Pedersen and Saltin, 2006). The ACSM and ADA joint position stand (Colberg et al., 2010) recommended that individuals with T2DM engage in at least 150 min·week⁻¹ of moderate-intensity aerobic physical activity (40–60% of VO₂max or 50–70% of maximum heart rate) and
/or at least 90 min·week⁻¹ of vigorous aerobic exercise (>60% of VO_{2max} or >70% of maximum heart rate). In the absence of contraindications, people with T2DM should be encouraged to perform resistance exercise at moderate intensity (50% 1-repetition maximum – 1-RM) or vigorous (75-80% 1-RM) two-three times·week⁻¹. It is recommended that structured, individually tailored education programmes for physical activity be available to all those with diabetes in the UK (NICE, 2011). However, despite a growing evidence base that substantiates the benefits of physical activity (Boulé et al., 2001; 2003; Sigal et al., 2004; Kelley and Kelley, 2007) and evolving diabetes specific physical activity recommendations and guidelines (Colberg et al., 2010) many individuals with T2DM remain inactive. A recent study suggesting only 30% of individuals with T2DM achieve the recommended guidelines for physical activity (Plotnikoff et al., 2011a) highlights that although the efficacy of physical activity may be proven, the disparity between evidence and compliance to physical activity behaviour among individuals with T2DM remains a challenge for researchers and healthcare providers.

Research has looked toward theoretical paradigms and investigated barriers in an attempt to better understand the factors affecting sedentary and physical activity behaviour among those with T2DM. A number of physical activity interventions (Marcus et al., 1999; 2000; Kim et al., 2004; Kirk et al., 2001; 2004; 2009) have utilised aspects of the TTM (Prochaska and DiClemente, 1982) in particular the SoC in order to classify physical activity behaviour and tailor advice in an effort to promote the behaviour. While the model has proven popular, outcomes have been varied. Proponents of the model, such as Marcus et al. (2000) and Kirk et al. (2004) suggest SoC for physical activity shows promise for achieving increased physical activity, enhanced readiness to adopt physical activity, and improved stage progress toward physical activity adherence. Whereas researchers (Adams and White, 2005; Bridle et al., 2005) who question the effectiveness of the TTM model and SoC suggest the model oversimplifies what is a complex behaviour and by focusing on personal motivation alone fails to recognise physical activity behaviour may be influenced by factors such as age, gender, and social support.

Studies investigating self-care behaviour have also utilised Bandura’s (1977) Self-efficacy Theory. While Wang and Shiu (2004) and Wu et al. (2007) provide support
for self-efficacy as an important predictor of self-care behaviour, they also urge caution suggesting self-efficacy alone does not predict the variation that is observed in adherence to self-management behaviours. This may be due in part to the task specific nature of perceived self-efficacy (Bandura, 1986) and the fact diabetes self-care involves managing multiple complex behaviours concurrently. Nonetheless, Self-efficacy Theory informed by its four main mechanisms; performance accomplishments, vicarious experiences, physiological arousal, and verbal persuasion maintains an inherent appeal particularly for researchers tasked with understanding and promoting self-care behaviours.

Rotter’s (1966) LoC Theory may help to explain variances in self-management behaviour. LoC Theory describes people’s perceptions and expectations about reinforcements for particular behaviours as being contingent on internal forces or on forces outside of the individual – powerful others and change. Research suggests that it is internal LoC which is paramount to performance of health behaviours (Coates and Boore, 1995; O’Hea et al., 2005). O’Hea et al. (2005) are however critical of the use of LoC, claiming researchers often focus on the internal dimension, frequently disregarding the other dimensions, powerful others and chance. Similarly to self-efficacy and its task specific nature, the validity of applying LoC to health-related behaviours has also been questioned as individuals may have a tendency towards internality in many life areas, but have an external belief with regard to the particular health-related behaviour. Furthermore, Trento et al. (2006; 2008) have provided evidence emphasising the need for population and behaviour specific tools when assessing LoC among individuals with diabetes.

Investigation of barriers to physical activity behaviour has also provided more information on factors which are thought to impact motivation for the behaviour. In a review of studies investigating physical activity behaviour among individuals with T2DM, Korkiakangas et al. (2009) identified internal and external barriers to regular physical activity. The authors suggested internal barriers included factors which could be influenced by the individual’s own decision-making, such as, lack of time and negative emotions such as shame, laziness and fear of exercise. The authors suggested internal barriers were dominant when individuals felt there were inadequate reasons, goals and benefits of exercise (health problems, exercise is not motivating) in
comparison to the costs of exercising (pain, tiredness, feeling that exercise is uncomfortable, negative emotions). Korkiakangas et al. (2009) presented external barriers as factors which were distinct from an individual’s inner decision-making. These factors prevented exercising through for example, lack of exercise facilities, and lack of social support. However, it has also been acknowledged that internal and external barriers are not dichotomous, but the two interact, for example, in the case of a caregiver, the internal barrier, perceived lack of time, could be closely aligned to lack of social support.

The mechanisms by which barriers and facilitators impact motivation and lead to inactivity or the adoption and maintenance of activity behaviour are not fully understood. Similarly, SoC, self-efficacy and LoC theories are not without limitations, however, available research indicates that using these paradigms in unison may offer further insight into how internal and external factors affect physical activity behaviour. For instance, Kennedy et al. (2001) have found that people in the preparation stage of change for physical activity behaviour tended towards higher levels of internal LoC. While O’Hea et al. (2009) have found internal LoC to be important regarding diabetes management, but only when interacting with two other perceived construct - self-efficacy and outcome expectancy. Furthermore, investigation of barriers and facilitators to physical activity and exercise behaviour in conjunction with theoretical paradigms may increase understanding and help researchers and healthcare professionals to promote this poorly adhered to self-care behaviour.

4.1.2 Study objectives

4.1.2.1 General objective

This cross-sectional study aimed to investigate physical activity behaviour, in relation to potential relationships which may exists between self-reported physical activity behaviour, other self-management behaviours, theoretical constructs, and demographics within a T2DM population.

Specifically, the theoretical constructs comprised SoC for physical activity behaviour (Marcus et al., 1992); diabetes self-efficacy (Rapley et al., 2003); and diabetes LoC (Ferraro et al., 1987). The demographic and care related variables included; duration
of diabetes; HbA$_1c$ (as a measure of average blood glucose control); co-morbidities; prescribed medications; and, physical activity or exercise advice provided by healthcare team. Self-management behaviours including; diet; physical activity; medication adherence; blood glucose testing; and foot care, were assessed using the Summary of Diabetes Self-Care Activities (SDSCA, Toobert et al., 2000) questionnaire.

4.1.2.2 Primary objectives

(1) To investigate potential relationships between self-management behaviours and the theoretical constructs of diabetes self-efficacy and LoC.

(2) To investigate differences between self-reported SoC for physical activity behaviour and reported self-management behaviour, theoretical constructs (diabetes self-efficacy and LoC), and demographic variables.

(3) Post-hoc objective: To investigate differences between healthcare advice reportedly received and reported self-management behaviour, theoretical constructs (diabetes self-efficacy and LoC), and demographic variables.

The primary objectives, collectively, sought to elucidate any predispositions, variations, or differences in individuals’ use of physical activity in the self-management of their T2DM.

4.2 Methods

4.2.1 Participants

A total of 260 T2DM patients were asked to complete a self-administered questionnaire whilst attending a regular appointment at a diabetes clinic, in Altnagelvin Hospital, Derry, Northern Ireland. 247 (95%) questionnaires were returned. Following exclusion of 37 incomplete questionnaires, a total of 210 (representing 81% of patients initially approached to complete the questionnaire) (male, n=124; female, n=86; median [range]: age, 61.4 [27.0-83.0] years; duration of diabetes, 10.3 [0.2-36.6] years; BMI, 33.6 [22.1-52.2] kg·m$^{-2}$; HbA$_1c$, 8.0 [5.2-14.0] %) returned questionnaires were included for data analysis.
Among the study population, 57 (27%) participants achieved a target HbA\textsubscript{1c} of \begin{math} \leq 7.0\% \end{math}, 69 (33%) participants had HbA\textsubscript{1c} of \begin{math} >7\% \text{ to } \leq 8.0\% \end{math} and 84 (40%) participants had HbA\textsubscript{1c} of \begin{math} >8.0\% \end{math}. Diabetes treatments included oral hypoglycaemic agents (41%), insulin (36%), or combination of oral agents and insulin (15%) while 9% reported no prescription. The inclusion criteria included participants with T2DM, male or female, inclusive of all age’s \begin{math} \geq 18\text{ years} \end{math}, be able to provide written informed consent, and English speaking. Patients with diabetes other than T2DM were excluded from the study as were patients with restricted physical mobility who required assistance when attending the diabetes clinic.

The study protocol was approved by University of Wales Institute Cardiff Ethics Committee, the Western Health and Social Care Trust Research Governance Committee and the Office for Research Ethics Committees Northern Ireland. All participants received written and verbal information regarding the nature of the study and they were required to provide signed informed consent prior to participating (Appendices 7, 8).

4.2.2 Instrument and measures

Participants completed a self-administered questionnaire (Appendix 9) containing four previously validated scales.

1) The Summary of Diabetes Self-Care Activities-revised (SDSCA) (Toobert et al., 2000): The SDSCA asked participants to report the frequency with which they performed various self-management activities over the previous 7 days whereby respondents report a score of \begin{math} 0-7 \text{ days} \cdot \text{week}^{-1} \end{math} for each activity. The items provided an overall score for each aspect of diabetes regimen – diet behaviour (Q26-31), physical activity behaviour (Q72-74), medication taking behaviour (Q21-23), blood glucose testing (Q12-14), foot care behaviour (Q15-20), smoking behaviour (Q24-25). Mean scores were collected for each self-care behaviour (Toobert et al., 2000). The SDSCA also provided multiple choice options where respondents reported on the recommendations they receive from their healthcare team. There is no scoring system for these items.

2) The stages of change (SoC) for physical activity behaviour scale (Q77) (adapted from Marcus et al., 1992): Using the SoC behaviour scale was used to assess
participant’s current level of physical activity. Participants read the following physical activity recommendation: “30 minutes of moderate intensity physical activity 5 days·week\(^{-1}\) or 3-5 days·week\(^{-1}\) of vigorous intensity activity for 20 minutes” and then placed themselves in one of the five stages: precontemplation (not physically active or intending to be within the next 6 months), contemplation (not physically active but considering becoming active within the next 6 months), preparation (doing some physical activity but not enough to meet physical activity guidelines), action (regularly physically active but for less than 6 months) or maintenance (regularly physically active and for more than 6 months).

3) The Diabetes Self-efficacy scale (Rapley et al., 2003): The scale is an 18-item measure for assessing participants’ confidence in their ability to follow; diabetic routines (Q32-35); self-treat (Q36-40); manage diabetes (Q41-44); diet routine (Q45-47); and exercise routine (Q48-49). Participants indicated their response to a given statement using a Likert scale ranging from 1=strongly disagree to 6=strongly agree. Participants mean score for each routine was then achieved by summing the Likert subscale responses. In turn participants’ total score for diabetes self-efficacy was achieved by summing the 5 Likert subscales.

4) The Diabetes Locus of Control scale (Ferraro et al., 1987): The scale is an 18-item measure containing 3 subscales (internal, Q54-59; powerful others, Q60-65; and chance, Q66-71) each consisting of 6 Likert items where participants indicated their response to a given statement on a scale ranging from 1=strongly disagree to 6=strongly agree. A mean score for each subscale was achieved by summing the Likert item responses.

The SDSCA is among the most widely used self-report instruments for measuring diabetes self-management in adults. The SDSCA measure includes scales for commonly recommended diabetes self-care behaviours (Toobert et al., 2000). In a review of studies using the original version of the SDSCA (Toobert and Glasgow, 1994), the test authors noted moderate test-retest correlations for the subscales over 3-4 months, and acceptable mean internal consistency. Validity for the original subscales has been supported by correlations of the SDSCA with other measures of diet and exercise (Nouwen et al., 1997; Talbot et al., 1997). As a culmination of their
review, the test authors created a revised version of the measure (Toobert et al., 2000). The SDSCA assesses levels of self-care and not adherence or compliance to a prescribed regimen because of the difficulties associated with identifying, for a given patient, a specific unchanging standard against which behaviour should be compared (Glasgow and Anderson, 1999). In the assessment of the reliability and validity of the SDSCA measure Toobert et al. (2000) have demonstrated the average inter-item correlations within scales were high (mean=0.47), with the exception of specific diet; test-retest reliability were moderate (mean=0.40). Correlations with other measures of diet and exercise generally supported the validity of the SDSCA subscales (mean=0.23).

The SoC for physical activity behaviour scale (Marcus et al., 1992) was derived from the TTM (Prochaska and DiClemente, 1982) which has been used to guide interventions for a number of health behaviours, including, smoking cessation and diet (Marcus et al., 1998a, 1998b), in a variety of settings such as communities (Marcus et al., 1992) and physicians' offices (Calfas et al., 1996). The SoC model proposes that individuals differ in their motivational readiness for change. They may be (1) not intending to change, (2) intending to change, (3) making small changes, (4) meeting a behaviour change criterion (e.g. meeting public health recommendations of accumulating ≥30 minutes of moderate-intensity activity on most days of the week), or (5) sustaining the change over time.

Staging algorithms have been increasingly used to assess physical activity level. In a single-question algorithm, each response option indicates one definite stage and the respondent has to classify themselves (Courneya, 1995; Haire-Joshu et al., 1999). The options are differentiated from one another by several critical components: awareness of the target behaviour, actual behaviour, time frame of the behaviour and intentions to change the behaviour. Self-assessment algorithms can be easily incorporated into questionnaires or questionnaires, however, the evaluation of these measures is complicated by inconsistencies in uses and only limited information is available on their adequacy. Adams and White (2005) who have emphasised the importance of accurately determining current SoC, suggest previous interventions have lacked validated algorithms to assess current activity stage. While it is accepted that validating staging algorithms is a complicated issue as no external criterion covers the
total array of stages (Wyse et al., 1995), Marttila and Nupponen (2003) argue the basic demand for accurate staging is that the target behaviour is explicit and discrete enough to allow for an unequivocal definition. In order to define non-overlapping stages, there is a need to have clearly stated criteria for the behaviour. In the case of exercise, Reed et al. (1997) have emphasised three criteria: frequency, time frame and intensity of the behaviour in question. In addition, all this has to be expressed in a lucid, understandable wording to avoid any confusion. The SoC scale (Marcus et al., 1992) has been used to assess individual’s current physical activity level (Marcus et al., 1992; Loughlan and Mutrie, 1995; Kirk et al., 2010) as well as in physical activity interventions (Marcus et al., 1998a, 1998b; Kirk et al., 2001; 2004; 2009). The test-retest reliability has been shown to range from moderate (mean=0.52, Donovan et al., 1998) to high (mean=0.78, Marcus et al., 1992) and Wyse et al. (1995) demonstrated construct validity of the measure was high among both males (mean=0.76) and females (mean=0.82).

The Diabetes Self-efficacy scale (Rapley et al., 2003) was developed from previous scales for use with both insulin and non-insulin dependant patients with diabetes and assessed 5 situations in which patient competence and confidence would be important. These situations consisted of: confidence in ability to follow diabetic routines; confidence in ability to self-treat; confidence in ability to manage diabetes; confidence in ability to manage diet; and, confidence in ability to exercise. In the assessment of the reliability and validity of the scale, Rapley et al. (2003) demonstrated that average inter-item consistency within the subscales were high (mean=0.71); test-retest reliability were also high (mean=0.83) whilst construct validity was more moderate (mean=0.53).

Ferraro et al. (1987) developed the Diabetes Locus of Control scale designed to measure three dimensions - internality, powerful other, and chance – in the context of diabetes specific management regimen. The ‘powerful others’ used by Ferraro et al. was defined broadly to include friends and family as well as other people with diabetes rather than limiting the scales to health professionals as many other scales do. Ferraro et al. (1987) did not appear to have attempted to balance their presentations of positive vs. negative outcomes in their items: the internal and powerful others items are predominantly concerned with control over positive outcomes, while the chance
items have more balance. In the assessment of the reliability and validity of the scale, Ferraro et al. (1987) demonstrated that average inter-item consistency within the subscales were high (mean=0.75); test-retest reliability were also high (mean=0.75) whilst validity was also demonstrated by significant correlations with the LoC scale developed previously by Wallston et al. (1978). Other diabetes specific questionnaires have been designed to measure LoC (Kohlmann et al., 1993; Peyrot and Rubin, 1994). These scales have expanded on the original three subscales, to include unpredictability however the scales have been designed specifically for insulin users.

The questionnaire also assessed participants demographic profile including: age; duration of diabetes; HbA1c (as a measure of average blood glucose control); BMI (as a measure of body composition); and co-morbidities (Q1-11). Participants were also assessed on past exercise activity levels throughout their lifespan (Q75) [exercise history]; asked to consider whether or not they believed exercise could assist with the control of their diabetes (Q76); whether they exercised independently (Q78); and, report reasons for not exercising (Q79).

4.2.3 Administrating the questionnaire

4.2.3.1 Pilot study

A pilot study involving five T2DM patients who were attending an outpatient diabetes clinic at Altnagelvin Hospital was conducted prior to the commencement of the main study. Participants who fulfilled the main study inclusion and exclusion criteria were recruited to the pilot study on an ad hoc basis, akin to the recruitment method that would be employed in the main study. Upon agreeing to participate, patients were asked to complete the questionnaire and afterwards provide feedback considering if they deemed the questions within the questionnaire to be suitable for them and their peers, whether the terms and wording of questions were easy to understand, the duration of time taken to complete the questionnaire, as well as provide any further comments they felt necessary. The participants of the pilot study judged the questionnaire to be suitable and no further editing or amendments were required.
4.2.3.2 Power calculation

The validated software G*Power (version 3.0) ([http://wwwpsychouni-duesseldorfred/de/abteilungen/aap/gpower3](http://www.psycho.uni-duesseldorfedde/abteilungen/aap/gpower3)) was used to establish required sample size for the present study. In this instance the following selections were made:

**Test family:** F tests (to include ANOVA and regression analysis)

**Statistical test:** ANOVA: fixed effects, omnibus, one-way

**Type of power analysis:** A priori - compute required sample size - given alpha, power, and effect size

- **Effect size:** 0.3 (medium effect size)
- **Alpha error probability:** 0.05
- **Power:** 0.95 (medium effect)
- **Number of groups:** 5

The number of groups (5) reflected the distinct sections of the questionnaire: 1) patient demographics; 2) SDSCA measures; 3) SoC for physical activity behaviour the Diabetes Self-efficacy scale; 4) self-efficacy measures; and 5) LoC measures. Finally the number of questions within each section was inputted (11, 19, 5, 18 and 18 respectively). The software provided a required sample size of 215.

4.2.3.3 Data collection

Upon arrival to the diabetes clinic at Altnagelvin Hospital all participants were provided with details about the study in the form of a Patient Information sheet (Appendix 7). Upon agreeing to participate all patients were asked to provide written informed consent by signing a Patient Consent sheet (Appendix 8) and were then invited to complete the self-administered questionnaire. A private area was available to all patients whilst completing the questionnaire and all questionnaires were coded to avoid identification of individual data. Table 4.1 displays the time period in weeks and months over which questionnaires were distributed to participants.

<table>
<thead>
<tr>
<th>Table 4.1 Timeline of questionnaire distribution</th>
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<tbody>
<tr>
<td>Month 1</td>
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<tr>
<td>Weeks</td>
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<tr>
<td>1</td>
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<tr>
<td>Total week&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Overall total</td>
</tr>
</tbody>
</table>

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4.2.4 Data analysis

4.2.4.1 Missing data

Of the 210 analysed questionnaires, responses to Questions 8a (highest qualification) and 8b (profession) were missing in n=173 (82.4%) and n=144 (68.6%) questionnaires respectively and were thus omitted from the data analysis. This action was not deemed detrimental to the data set on the basis that neither Question 8a nor 8b were intended to form key themes within the analysis. In the case of random missing data, substituted values (overall mean) were imputed for the missing values. Allison (2002) criticises this method suggesting substituting missing values with overall means can produce standard errors that are underestimated and test statistics that are overestimated. However, Cohen et al. (2003) argue the advantages of this method include: avoids risk of non-representativeness in dropping subjects if missing data are non-random; avoids loss of statistical power due to reduced n; capitalises on information inherent in the absence-presence of values on the variable in question; and also capitalises on the information present on other variables although missing for some subjects on the variable in question.

4.2.4.2 Creating variables

Combined or totalling of responses produced composite scores creating the following variables: total co-morbidities; total medication; and level of physical activity or exercise advice. The variable exercise behaviour change was also created by collapsing the five stages of change levels, to form three distinct exercise behaviour change groups – group I (precontemplators/contemplators), group II (preparation) and group III (action/maintenance). It was anticipated classification of participants into distinct groups of exercise behaviour change could further assist investigation and understanding of factors affecting motivation for initiation and maintenance of behaviour for two reasons. One, the stage definitions proposed by Marcus and colleagues (1992) posit that individuals in precontemplation and contemplation differ only in terms of their intention to exercise (nonintenders vs. intenders, respectively), whilst those in action and maintenance differ only in the duration of their current involvement in regular exercise (less than 6 vs. 6 or more months, respectively). Further, Woods et al. (2002) previously highlighted the SoC studies demonstrated that the different stages on the SoC instrument significantly differentiated an individuals activity levels into regularly (action/maintenance) or not regularly active.
Collapsing of five stages to form three categories allowed for a comparison of three distinct groups which were regularly active (Group III), active but not meeting recommendations (Group II), and inactive (Group I). Secondly, the creation of three exercise behaviour change groups from the initial five SoC groups also allowed for more robust between group statistical analysis to be performed by effectively increasing the sample size of each group, especially appropriate given the small number of participants who reported being at the action and maintenance stages.

4.2.4.3 Statistical analysis

Descriptive analysis of participant demographics, self-management behaviours, self-efficacy, LoC, past and present physical activity behaviour and perceived SoC for physical activity behaviour were performed. Normality was determined using the Kolmogorov-Smirnov goodness-of-fit test for continuous data; all data did not meet the assumptions for parametric statistics and were expressed as median [range]. The non-parametric Spearman’s rank correlation coefficient analysis was conducted to investigate the strength and direction of any linear relationship between the dependent variables and the independent or predictor variables. Direction and strength of relationships (rho value), and statistical significance set at P<0.05 were reported. Following stratification of the data set into three categories of exercise behaviour change groups the non-parametric Kruskall-Wallis test was performed as a non-parametric one-way analysis of variance by rank between data sets of three or more groups. Due to unequal group sizes post hoc between groups analysis was conducted using the Mann-Whitney U test. Statistical significance was set at P<0.05. All statistical analysis was performed using SPSS (SPSS, Incorporated, Chicago, Windows version 17.0).

4.3 Results

For diabetes self-management behaviours, medication adherence was reported on average 7 [0-7] days·week\(^{-1}\) while blood glucose testing and diet self-management behaviour were reported as 5 [0-7] days·week\(^{-1}\) and 4 [0-7] days·week\(^{-1}\) respectively. Thirty minutes of physical activity was achieved on average 2 [0-7] days·week\(^{-1}\) and structured exercise 3 [0-7] days·week\(^{-1}\). For measures of diabetes self-efficacy, on average participants reported 4.8 [1.0-6.0] and 4.8 [1.0-6.0] for adherence to routine and self-treatment respectively whilst self-efficacy to follow diet and exercise routines
were reported as 4.1 [1.0-6.0] and 3.6 [1.0-6.0]. In terms of LoC, participants reported an average score of 4.9 [1.0-6.0] for internal LoC, 3.6 [1.0-6.0] for powerful others LoC and 2.4 [1.0-6.0] for chance LoC. On average, study participants patients reported having two other co-morbidities while 26 reported no complications. The most frequent co-morbidities reported were hypertension (n=147) and hypercholesterolemia (n=143) with 116 patients reporting both of these conditions. Other common combinations of co-morbidities included retinopathy (n=32 [31 combined with hypertension]) and angina (n=30 [27 combined with hypercholesterolemia]).

Results of Spearman’s rank correlation coefficient analyses between glycaemic control, self-management behaviours, measures of diabetes self-efficacy and diabetes LoC are displayed in Table 4.2. Glycaemic control (HbA1c) was significantly correlated with self-efficacy to exercise and powerful others LoC. A number of significant correlations between self-management behaviours, diabetes self-efficacy and diabetes LoC measures were also observed, including testing of blood glucose with self-efficacy to self-treat and chance LoC. Diet self-management behaviour was observed to correlate self-efficacy to exercise, internal LoC and powerful others LoC. Exercise self-management behaviour was correlated with self-efficacy to adhere to routine, self-efficacy to exercise and powerful others LoC.
<table>
<thead>
<tr>
<th></th>
<th>Adherence to medication</th>
<th>Testing of blood glucose</th>
<th>Feet self-management</th>
<th>Diet self-management</th>
<th>Exercise self-management</th>
<th>SE to adhere to routine</th>
<th>SE to self treat</th>
<th>SE certainty</th>
<th>SE to follow a diet</th>
<th>SE to exercise</th>
<th>Internal LoC</th>
<th>Powerful others LoC</th>
<th>Chance LoC</th>
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<tbody>
<tr>
<td><strong>HbA1c</strong></td>
<td>0.091</td>
<td>-0.004</td>
<td>-0.034</td>
<td>0.052</td>
<td>-0.10</td>
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</tr>
<tr>
<td><strong>Adherence to medication</strong></td>
<td>0.133</td>
<td>-0.285</td>
<td>0.037</td>
<td>0.063</td>
<td>0.111</td>
<td>0.056</td>
<td>0.156</td>
<td>0.058</td>
<td>-0.040</td>
<td>-0.085</td>
<td>-0.053</td>
<td>-0.132</td>
<td>rho</td>
</tr>
<tr>
<td></td>
<td>NS</td>
<td>0.037</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>0.023</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td><strong>Testing of blood Glucose</strong></td>
<td>-0.010</td>
<td>0.213</td>
<td>0.005</td>
<td>-0.069</td>
<td>0.290</td>
<td>0.045</td>
<td>0.031</td>
<td>0.095</td>
<td>0.110</td>
<td>-0.090</td>
<td>-0.165</td>
<td>-0.017</td>
<td>rho</td>
</tr>
<tr>
<td></td>
<td>NS</td>
<td>0.002</td>
<td>NS</td>
<td>0.001</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>0.017</td>
<td>P</td>
</tr>
<tr>
<td><strong>Feet self-management</strong></td>
<td>0.204</td>
<td>0.00</td>
<td>-0.119</td>
<td>0.114</td>
<td>0.250</td>
<td>0.052</td>
<td>0.204</td>
<td>-0.279</td>
<td>-0.103</td>
<td>-0.138</td>
<td>-0.138</td>
<td>-0.137</td>
<td>rho</td>
</tr>
<tr>
<td></td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td><strong>Diet self-management</strong></td>
<td>0.127</td>
<td>0.132</td>
<td>0.194</td>
<td>0.212</td>
<td>0.100</td>
<td>0.312</td>
<td>0.139</td>
<td>0.186</td>
<td>0.137</td>
<td>-0.137</td>
<td>NS</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td></td>
<td>NS</td>
<td>NS</td>
<td>0.005</td>
<td>0.002</td>
<td>NS</td>
<td>0.001</td>
<td>0.044</td>
<td>0.007</td>
<td>0.047</td>
<td>-0.007</td>
<td>0.047</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td><strong>Exercise self-management</strong></td>
<td>0.181</td>
<td>0.112</td>
<td>-0.022</td>
<td>0.079</td>
<td>0.384</td>
<td>0.091</td>
<td>0.176</td>
<td>0.089</td>
<td>0.011</td>
<td>NS</td>
<td>NS</td>
<td>P</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>0.008</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>0.001</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>0.011</td>
<td>NS</td>
<td>NS</td>
<td>P</td>
<td>P</td>
</tr>
</tbody>
</table>

**KEY:** *, n=54; LoC, locus of control; NS, non-significant; SE, self-efficacy. Data are rho value indicated when level of statistical significance is P≤0.05.
The variable, exercise behaviour change, consisted of three distinct groups – I (precontemplators/contemplators), II (preparation) and III (action/maintenance). Participants were stratified into the three groups based on their response to the SoC measure. Median and range data for participant descriptors, self-management behaviours, self-efficacy and LoC following stratification into these groups (I, II or III) are presented in Table 4.3. Statistically significant between-group differences were observed for physical activity, structured exercise, exercise self-management behaviour, exercise history, level of physical activity or exercise advice received from healthcare team, exercise self-efficacy and internal LoC. Duration of diabetes, total co-morbidities and total medication did not differ significantly across the three groups.

<table>
<thead>
<tr>
<th>Measure</th>
<th>I (n=50)</th>
<th>II (n=131)</th>
<th>III (n=29)</th>
<th>Between-group P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration of diabetes (years)</td>
<td>11.3 [0.2-36.6]</td>
<td>10.0 [0.3-30.3]</td>
<td>9.5 [0.2-18.2]</td>
<td>NS NS NS</td>
</tr>
<tr>
<td>HbA1c (%)</td>
<td>7.9 [5.2-14.0]</td>
<td>8.1 [5.3-13.7]</td>
<td>7.8 [5.6-11.1]</td>
<td>NS NS NS</td>
</tr>
<tr>
<td>Physical activity (days·week⁻¹)</td>
<td>1 [0-4]</td>
<td>3 [0-7]</td>
<td>5 [1-7]</td>
<td>0.001 0.001 0.001</td>
</tr>
<tr>
<td>Structured exercise (days·week⁻¹)</td>
<td>1 [0-4]</td>
<td>3 [0-7]</td>
<td>5 [1-7]</td>
<td>0.001 0.001 0.001</td>
</tr>
<tr>
<td>Exercise history</td>
<td>2.2 [0.0-3.6]</td>
<td>2.7 [0.0-3.8]</td>
<td>3.3 [2.0-4.0]</td>
<td>0.001 0.001 0.001</td>
</tr>
<tr>
<td>Level of physical activity or exercise advice</td>
<td>1.1 [0.0-4.0]</td>
<td>1.5 [0.0-4.0]</td>
<td>2.1 [0.0-4.0]</td>
<td>0.024 0.043 0.002</td>
</tr>
<tr>
<td>Adherence to medication routine (days·week⁻¹)</td>
<td>7 [0-7]</td>
<td>7 [0-7]</td>
<td>7 [0-7]</td>
<td>NS NS NS</td>
</tr>
<tr>
<td>Testing of blood glucose (days·week⁻¹)</td>
<td>5 [0-7]</td>
<td>4 [0-7]</td>
<td>4 [0-7]</td>
<td>NS NS NS</td>
</tr>
<tr>
<td>*Feet self-management (days·week⁻¹)</td>
<td>4 [1-6]</td>
<td>5 [2-7]</td>
<td>4 [3-5]</td>
<td>NS NS NS</td>
</tr>
<tr>
<td>Diet self-management (days·week⁻¹)</td>
<td>4 [0-7]</td>
<td>4 [0-7]</td>
<td>5 [3-7]</td>
<td>NS NS NS</td>
</tr>
<tr>
<td>Exercise self-management (days·week⁻¹)</td>
<td>1 [0-4]</td>
<td>3 [0-7]</td>
<td>5 [1-7]</td>
<td>0.001 0.001 0.001</td>
</tr>
<tr>
<td>SE to adhere to routine</td>
<td>4.6 [1.0-6.0]</td>
<td>4.8 [1.0-6.0]</td>
<td>5.3 [2.0-6.0]</td>
<td>NS NS NS</td>
</tr>
<tr>
<td>SE to self treat</td>
<td>4.8 [1.6-6.0]</td>
<td>4.7 [1.4-6.0]</td>
<td>5.3 [3.6-6.0]</td>
<td>NS NS NS</td>
</tr>
<tr>
<td>SE certainty</td>
<td>4.2 [1.0-6.0]</td>
<td>4.2 [1.0-6.0]</td>
<td>4.6 [1.0-6.0]</td>
<td>NS NS NS</td>
</tr>
<tr>
<td>SE to follow a diet</td>
<td>4.3 [1.0-6.0]</td>
<td>4.0 [1.0-6.0]</td>
<td>4.4 [1.0-6.0]</td>
<td>NS NS NS</td>
</tr>
<tr>
<td>SE to exercise</td>
<td>3.1 [1.0-5.5]</td>
<td>3.6 [1.0-5.8]</td>
<td>4.3 [1.0-6.0]</td>
<td>0.018 0.007 0.001</td>
</tr>
<tr>
<td>Internal LoC</td>
<td>4.9 [1.0-6.0]</td>
<td>4.8 [2.7-6.0]</td>
<td>5.3 [2.7-6.0]</td>
<td>NS 0.016 NS</td>
</tr>
<tr>
<td>Powerful others LoC</td>
<td>3.6 [1.0-6.0]</td>
<td>3.6 [1.0-6.0]</td>
<td>4.0 [3.0-6.0]</td>
<td>NS NS NS</td>
</tr>
<tr>
<td>Chance LoC</td>
<td>2.3 [1.0-6.0]</td>
<td>2.4 [1.0-6.0]</td>
<td>2.6 [1.0-6.0]</td>
<td>NS NS NS</td>
</tr>
</tbody>
</table>

Table 4.3 Median [range] participant descriptors, self-reported management behaviours, self-efficacy and locus of control measures in relation to exercise behaviour change

**KEY:** * group I, (n=12); group II, (n=35); group III, (n=7); LoC, locus of control; NS, non-significant; SE, self-efficacy. Level of statistical significance shown when P≤0.05.

The distribution of co-morbidities, diabetes medication, physical activity or exercise advice and reasons provided for not exercising for respective exercise behaviour change groups are displayed in Table 4.4. The most commonly reported co-morbidities across the three groups were hypertension and hypercholesterolemia whilst retinopathy was also reported as a common co-morbidity among participants in groups I and II. A greater number of participants group III, reported prior myocardial infarction and stroke in comparison to participants from groups I and II. For diabetes medication, few participants from groups I, II and III respectively reported no prescription while the majority of participants from each of the three groups used one
Among the three exercise behaviour change groups, participants most commonly reported receiving one piece of advice which was *low level exercise daily*. The second most frequently received advice across the three groups was, *fit exercise into daily routine* while around half the participants in group III also received advice, *exercise continuously for 20 min 3 times·week*.

---

Table 4.4 Distribution (n [%]) of co-morbidities, prescribed medication, physical activity or exercise advice and reasons for not exercising in relation to exercise behaviour change

<table>
<thead>
<tr>
<th>Measure</th>
<th>Exercise behaviour change</th>
<th>I (n=50)</th>
<th>II (n=131)</th>
<th>III (n=29)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total co-morbidities</strong></td>
<td>None</td>
<td>5 [10.0%]</td>
<td>18 [13.7%]</td>
<td>7 [24.1%]</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>14 [28.0%]</td>
<td>26 [19.8%]</td>
<td>9 [31.0%]</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>13 [26.0%]</td>
<td>49 [37.4%]</td>
<td>4 [13.8%]</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>10 [20.0%]</td>
<td>31 [23.7%]</td>
<td>5 [17.2%]</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>8 [16.0%]</td>
<td>6 [4.6%]</td>
<td>3 [10.3%]</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>0 [0.0%]</td>
<td>1 [0.8%]</td>
<td>1 [3.4%]</td>
</tr>
<tr>
<td><strong>Co-morbidities</strong></td>
<td>Hypertension</td>
<td>34 [68.0%]</td>
<td>95 [72.5%]</td>
<td>18 [62.1%]</td>
</tr>
<tr>
<td></td>
<td>Hypercholesterolemia</td>
<td>37 [74.0%]</td>
<td>92 [70.2%]</td>
<td>15 [51.7%]</td>
</tr>
<tr>
<td></td>
<td>Angina</td>
<td>12 [24.0%]</td>
<td>14 [10.7%]</td>
<td>4 [13.8%]</td>
</tr>
<tr>
<td></td>
<td>Prior myocardial infarction</td>
<td>3 [6.0%]</td>
<td>11 [8.4%]</td>
<td>4 [13.8%]</td>
</tr>
<tr>
<td></td>
<td>Prior stroke</td>
<td>1 [2.0%]</td>
<td>1 [0.8%]</td>
<td>5 [17.2%]</td>
</tr>
<tr>
<td></td>
<td>Atherosclerosis</td>
<td>3 [6.0%]</td>
<td>3 [2.3%]</td>
<td>0 [0.0%]</td>
</tr>
<tr>
<td></td>
<td>Retinopathy</td>
<td>8 [16.0%]</td>
<td>23 [17.6%]</td>
<td>1 [3.4%]</td>
</tr>
<tr>
<td></td>
<td>Arthritis</td>
<td>3 [6.0%]</td>
<td>4 [3.1%]</td>
<td>1 [3.4%]</td>
</tr>
<tr>
<td></td>
<td>Diabetes related foot problems</td>
<td>1 [2.0%]</td>
<td>3 [2.3%]</td>
<td>1 [3.4%]</td>
</tr>
<tr>
<td><strong>Total medication</strong></td>
<td>No prescription</td>
<td>4 [8.0%]</td>
<td>8 [6.1%]</td>
<td>6 [20.7%]</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>40 [80.0%]</td>
<td>108 [82.4%]</td>
<td>18 [62.1%]</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>6 [12.0%]</td>
<td>15 [11.5%]</td>
<td>5 [17.2%]</td>
</tr>
<tr>
<td><strong>Medications</strong></td>
<td>Insulin 1-2 times·day(^1)</td>
<td>18 [36.0%]</td>
<td>51 [38.9%]</td>
<td>13 [44.8%]</td>
</tr>
<tr>
<td></td>
<td>Insulin ≥ 3 times·day(^1)</td>
<td>3 [6.0%]</td>
<td>15 [11.5%]</td>
<td>1 [3.4%]</td>
</tr>
<tr>
<td></td>
<td>Oral hypoglycaemic agents</td>
<td>31 [62.0%]</td>
<td>72 [55.0%]</td>
<td>15 [51.7%]</td>
</tr>
<tr>
<td><strong>Level of physical activity or exercise advice</strong></td>
<td>No advice</td>
<td>14 [28.0%]</td>
<td>19 [14.5%]</td>
<td>2 [6.9%]</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>23 [46.0%]</td>
<td>61 [46.6%]</td>
<td>13 [44.8%]</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>9 [18.0%]</td>
<td>30 [22.9%]</td>
<td>2 [6.9%]</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3 [6.0%]</td>
<td>14 [10.7%]</td>
<td>5 [17.2%]</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>1 [2.0%]</td>
<td>7 [5.3%]</td>
<td>7 [24.1%]</td>
</tr>
<tr>
<td><strong>Advice</strong></td>
<td>Low level exercise daily</td>
<td>29 [58.0%]</td>
<td>98 [74.8%]</td>
<td>21 [72.4%]</td>
</tr>
<tr>
<td></td>
<td>Exercise continuously 20 min, 3 times·week(^1)</td>
<td>8 [16.0%]</td>
<td>22 [16.8%]</td>
<td>15 [51.7%]</td>
</tr>
<tr>
<td></td>
<td>Fit exercise into daily routine(^2)</td>
<td>17 [34.0%]</td>
<td>56 [42.7%]</td>
<td>15 [51.7%]</td>
</tr>
<tr>
<td></td>
<td>Engage in specific exercise</td>
<td>3 [6.0%]</td>
<td>15 [11.5%]</td>
<td>9 [31.0%]</td>
</tr>
<tr>
<td><strong>Reasons for not exercising</strong></td>
<td>I do not see the point in exercising</td>
<td>1 [2.0%]</td>
<td>1 [0.8%]</td>
<td>0 [0.0%]</td>
</tr>
<tr>
<td></td>
<td>I am afraid or anxious to exercise</td>
<td>1 [2.0%]</td>
<td>4 [3.1%]</td>
<td>0 [0.0%]</td>
</tr>
<tr>
<td></td>
<td>I do not have the time</td>
<td>1 [2.0%]</td>
<td>5 [3.8%]</td>
<td>0 [0.0%]</td>
</tr>
<tr>
<td></td>
<td>I have other health problems</td>
<td>35 [70.0%]</td>
<td>53 [40.5%]</td>
<td>2 [6.9%]</td>
</tr>
<tr>
<td></td>
<td>I do not like exercising</td>
<td>0 [0.0%]</td>
<td>1 [0.8%]</td>
<td>0 [0.0%]</td>
</tr>
<tr>
<td></td>
<td>Exercise tires me out</td>
<td>1 [2.0%]</td>
<td>2 [3.6%]</td>
<td>0 [0.0%]</td>
</tr>
<tr>
<td></td>
<td>Exercise is too expensive</td>
<td>0 [0.0%]</td>
<td>1 [0.8%]</td>
<td>0 [0.0%]</td>
</tr>
<tr>
<td></td>
<td>I weigh too much</td>
<td>2 [4.0%]</td>
<td>0 [0.0%]</td>
<td>0 [0.0%]</td>
</tr>
</tbody>
</table>
Relative to the group size, more group III participants received three or four pieces of advice in comparison to participants in groups I and II.

Participants were stratified into five groups (0-4) based on the level of self-reported physical activity or exercise advice received from their healthcare team. Median and range data for participant descriptors, self-management behaviours, self-efficacy and LoC in relation to the level of physical activity or exercise advice reported to have been received are presented in Table 4.5. Based on the level of physical activity or exercise advice reportedly received, significant between-group differences were observed throughout the range of 0 to 4 levels of advice. P value outcomes (see Table 4.5) indicate statistically significant between-group differences were observed most frequently where participants were grouped 0 compared to 4, and 1 compared to 4 for levels of physical activity or exercise advice reportedly received from their healthcare team. For levels of advice 0 vs. 4: physical activity, structured exercise, exercise self-management behaviour, exercise history, exercise behaviour change, and internal LoC were significantly different. For levels of advice 1 vs. 4: physical activity, structured exercise, exercise self-management behaviour, exercise behaviour change, self-efficacy to adhere to routine, and self-efficacy to exercise were significantly different. Statistically significant between-group differences were also observed when participants were grouped 1 compared to 2 and, 2 compared to 4 for level of reported physical activity or exercise advice from the healthcare team for a total of three and four variables respectively. For levels of advice 1 vs. 2: self-efficacy to adhere to routine, self-efficacy to exercise, and internal LoC were significantly different. For levels of advice 2 vs. 4: physical activity, structured exercise, exercise self-management behaviour, and exercise behaviour change were significantly different.
### Table 4.5 Median [range] participant descriptors, self-reported management behaviours, self-efficacy and locus of control measures in relation to level of physical activity or exercise advice

<table>
<thead>
<tr>
<th>Measure</th>
<th>0 (n=35)</th>
<th>1 (n=97)</th>
<th>2 (n=41)</th>
<th>3 (n=22)</th>
<th>4 (n=15)</th>
<th>0-1</th>
<th>0-2</th>
<th>0-3</th>
<th>0-4</th>
<th>1-2</th>
<th>1-3</th>
<th>1-4</th>
<th>2-3</th>
<th>2-4</th>
<th>3-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration of diabetes (years)</td>
<td>11.9[1.3-33.9]</td>
<td>10.7[2.2-36.6]</td>
<td>10.0[0.3-33.0]</td>
<td>7.1[0.6-15.0]</td>
<td>9.0[1.0-17.0]</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>HbA1c (%)</td>
<td>8.0[5.7-14.0]</td>
<td>7.8[5.2-13.7]</td>
<td>8.5[5.3-12.6]</td>
<td>8.1[6.2-10.1]</td>
<td>8.0[6.5-11.1]</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Physical activity (days/week)</td>
<td>3[0-7]</td>
<td>3[0-7]</td>
<td>3[0-7]</td>
<td>3[0-7]</td>
<td>4[0-7]</td>
<td>NS</td>
<td>NS</td>
<td>0.004</td>
<td>NS</td>
<td>0.004</td>
<td>NS</td>
<td>0.008</td>
<td>NS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structured exercise (days/week)</td>
<td>2[0-7]</td>
<td>2[0-7]</td>
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<td>3[0-7]</td>
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<td>0.002</td>
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<td>2.7[0.0-4.0]</td>
<td>2.7[1.0-3.7]</td>
<td>2.8[1.0-4.0]</td>
<td>4.0[1.0-4.0]</td>
<td>NS</td>
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<tr>
<td>Adherence to medication (days/week)</td>
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<td>1.8[1.0-3.0]</td>
<td>2.1[1.0-3.0]</td>
<td>2.4[1.0-3.0]</td>
<td>0.044</td>
<td>NS</td>
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<td>Testing blood glucose (days/week)</td>
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<td>7[0-7]</td>
<td>6[0-7]</td>
<td>7[0-7]</td>
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<td>*Feet self-management (days/week)</td>
<td>5[0-7]</td>
<td>5[0-7]</td>
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<td>3[0-7]</td>
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<tr>
<td>Exercise self-management (days/week)</td>
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<td>3[0-7]</td>
<td>5[0-7]</td>
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<td>NS</td>
<td>0.003</td>
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**Key:** *, group 0, (n=17); group 1, (n=20); group 2, (n=9); group 3, (n=4); group 4, (n=4); LoC, locus of control; NS, non-significant; SE, self-efficacy. Level of statistical significance shown when P≤0.05.
4.4 Discussion
The present study, a cross-sectional investigation of 210 patients attending an outpatient diabetes clinic, sought to explore potential relationships between physical activity behaviour, other self-management behaviours, and theoretical constructs. More specifically, the study sought to elucidate any predispositions and variations, affecting in individuals’ use of physical activity in the self-management of their T2DM.

4.4.1 Self-efficacy and locus of control
A number of weak but statistically significant correlations between glycaemic control (HbA1c), self-management behaviours, and measures of diabetes self-efficacy and diabetes LoC measures were observed. Self-efficacy to exercise and others LoC were observed to be positively correlated with glycaemic control (HbA1c). Adherence to medication routine was observed to be positively correlated with self-efficacy certainty, while testing of blood glucose was found to be positively correlated with self-efficacy to self-treat and negatively correlated with chance LoC. Diet self-management behaviour was observed to correlate positively with self-efficacy to self-treat, self-efficacy certainty, self-efficacy to exercise, internal and powerful others LoC. Exercise self-management behaviour - reflecting daily physical activity and structured exercise - was positively correlated with self-efficacy to adhere to routine, self-efficacy to exercise and powerful others LoC.

Self-efficacy is posited to be dynamic, task specific, and influenced by four primary mechanisms: performance accomplishments, vicarious experiences, physiological arousal, and verbal persuasion (Bandura, 1997). The predictive ability of self-efficacy to exercise in the present study has been supported in previous studies where self-efficacy has been shown to predict several health-related behavioural changes (Krichbaum et al., 2003), including physical activity behaviour among individuals with diabetes (Plotnikoff et al., 2011b). Despite the apparent merits of higher levels of self-efficacy and contributions of Self-efficacy Theory to understanding changes in physical activity behaviour, few theory based interventions incorporating aspects of self-efficacy which targeted physical activity in individuals with diabetes have proven to be practical and effective (Kirk et al., 2001, 2004, 2009; DiLoreto et al., 2003; Tudor-Locke et al., 2004). This highlights the difficulties associated with promoting
sustained, regular involvement in physical activity and/or exercise and acknowledges the danger of oversimplifying this complex behaviour. The importance of instructors, coaches, friends and health professionals to behaviour change has been acknowledged in LoC theory. LoC refers to individuals perceptions and expectations about reinforcements for particular behaviours being contingent on individual forces or on forces external to the individual and has been used to explain outcomes such as metabolic control in terms of two factors: 1) internal LoC or personal effort, and 2) external LoC, inclusive of powerful others or chance (Tillotson et al., 1996; Trento et al., 2006; O’Hea et al., 2009).

In the present study self-efficacy for diabetes self-management behaviours was observed to be task specific and independent from one behaviour to another. For example, an individuals’ confidence in ability to take their medication differed from their confidence in ability to test their blood glucose level (self-efficacy certainty vs. self-efficacy to self treat). While only limited conclusions can be drawn from the present study, the implications of these observations are better demonstrated by Zulman et al. (2011) who recently demonstrated that task specific self-efficacy and disease related emotional distress were important determinants of self-management behaviour and subsequent glycaemic control. In the case of physical activity behaviour, Bandura (1997) suggest the prime predictive factors of self-efficacy for physical activity operate directly and indirectly. The direct motivators of self-efficacy are people’s level of belief in their capability to control their behaviour and outcome expectancies while indirect motivators reflect factors external to the individual. Interestingly, in the present study self-efficacy to exercise was significantly and positively related to glycaemic control (HbA1c) as demonstrated by Spearman’s correlation. Exercise self-management behaviour was found to correlated with both self-efficacy to exercise and powerful others locus of control. Similarly, other self-management behaviours were observed to correlate with different aspects of self-efficacy and LoC. For instance, testing blood glucose and diet self-management behaviour, although positively correlated together, diet self-management behaviour was positively correlated with internal and powerful others LoC, whilst blood glucose testing was not. This suggests LoC orientations, internal LoC (reflecting acceptance of personal responsibility on the behalf of the patient for this part of their diabetes self-management regime) and powerful others LoC (inclusive of friends, family and
healthcare team) may play an important role in some diabetes self-management behaviour, but not others. Both diet self-management and exercise self-management behaviour were found to be positively correlated with self-efficacy to exercise and powerful others LoC. Thus, while self-efficacy for a behaviour may appear important, the influence of friends, family and healthcare team, may also play an important role in self-management behaviour. This observation supports the important relationship between self-efficacy and LoC advocated by previous research (Collins et al., 2009; O’Hea et al., 2009) as well previous findings which emphasise the importance of peer and healthcare provider support in assisting individuals with T2DM to initiate and maintain physical activity behaviour (Casey et al., 2010). However, unlike diet, exercise self-management behaviour was not associated with internal LoC, suggesting participants in this study may have externalised perceived behavioural control of exercise self-management. Given, Gatt and Sammut (2008) suggest perceived behavioural control is predictive of actual self-care behaviour, strategies to improve exercise self-care behaviour among individuals with T2DM should focus on improving individuals perception of behavioural control. The influence of external factors and the possibility that exercise self-management behaviour is yet to be internalised for most of the study population, may be further indicated by exercise being the only self-management behaviour to be significantly correlated with self-efficacy adherence to routine. It is plausible that unlike other self-management behaviours which may have already become internalised, exercise self-management behaviour may still be perceived as being regimental or routine-like, and therefore not fully integrated into patients’ daily living activities. In recent years physical activity promotion has undergone a paradigm shift away from concerns for fitness towards active living, however the present study suggests there may remain a need to further emphasise flexibility and merging of physical activity into daily life among individuals with T2DM.

4.4.1 Exercise behaviour change

Based on responses to the SoC measure participants were stratified into three exercise behaviour change groups: group I (n=50 [23.8%]) were assessed to be in precontemplation and contemplation – inactive; group II (n=131 [62.4%]) were in preparation - physically active, but not achieving the recommended level of physical activity, and group III (n=29 [13.8%]) consisted of participants in action or
maintenance – regularly achieving the recommended level of physical activity.

Following stratification and between-group analyses significant differences were observed for physical activity (days·week\(^{-1}\)), structured exercise (days·week\(^{-1}\)), exercise self-management behaviour (days·week\(^{-1}\)), exercise history, level of physical activity or exercise advice reportedly received, exercise self-efficacy and internal LoC. Although it appears that reported physical activity and structured exercise levels increase in accordance with increasing exercise behaviour change stages I-III, it is the significant between-group differences for exercise history, level of physical activity or exercise advice reportedly provided by healthcare team, exercise self-efficacy, and internal LoC which also increased across ascending exercise behaviour change groups that are of particular interest.

The theory of self-efficacy proposes that patients’ confidence in their ability to perform health behaviours influences which behaviours they will engage in (Bandura, 1997; Lorig and Holman, 2003). Observations of increasing exercise history in conjunction with increasing levels of physical activity and structured exercise across exercise behaviour change groups suggests past experience may play an important role in current behaviour. Of the self-efficacy mechanisms described by Bandura (1986), performance accomplishment may best explain the observations concerning exercise behaviour change and exercise history. Bandura suggested performance accomplishments are the most influential source of efficacy information because they are derived from the experience of mastering a behaviour (Bandura, 1986, 1997). Bandura (1986) also proposed that failures with novel tasks markedly lowers efficacy for that task. Among the present study cohort, it is plausible that individuals who successfully participate in physical activity and exercise over the course of their lifetime may be more likely to report currently achieving the recommended level of physical activity – as in the case of participants of exercise behaviour change group III. In comparison, participants in group I, also reported lower levels for exercise history (2.2 vs. 3.3). Among the current study cohort, it is possible that current physical activity levels among participants of both group I and III may have been influenced by past physical inactivity or activity respectively.

Exercise history, in conjunction with statistically significant differences in current self-efficacy to exercise between group I and III (3.1 vs. 4.3) lend further support to
the suggestion that current activity levels may be influenced by previous experiences of physical activity. For instance, negative perceptions of past experience may in turn be detrimental to patients current self-efficacy to exercise perceptions and subsequently their current level of physical activity and exercise behaviour. In contrast, if previous perceptions of physical activity or exercise were positive - whereby activities were successfully completed on a regular basis - task specific self-efficacy would likely increase (Bandura, 1997). While low self-efficacy has been reported to be among the strongest and most consistent barriers to diabetes self-management (Glasgow et al., 2001), individuals whose exercise self-efficacy has been influenced by previous performance accomplishment (Bandura, 1986) may be less likely to perceive barriers to physical activity and exercise behaviour.

Higher levels of exercise self-efficacy and stronger exercise control (perceived control over exercise levels) beliefs have been found to independently predict higher physical activity levels among older community-dwelling adults (Harris et al., 2009). Significant differences for internal LoC were observed between exercise behaviour change groups II and III (4.8 vs. 5.3). Similarly to self-efficacy, it is recognised that an individual may have a tendency towards internality in many life areas, but have an external belief with regard to other behaviours (Carlise-Frank, 1991). The relationship between LoC and health-facilitating behaviour, in this instance exercise behaviour change, points toward internal LoC as a mediating factor of actions taken to prevent health problems (Lefcourt and Davidson-Katz, 1991; Carlise-Frank, 1991). Sonstrøem and Walker (1973) suggest individuals with higher internal LoC have more favourable attitudes towards physical activity, obtain significantly better fitness scores, and engage in greater amounts of voluntary physical exercise than externals (e.g. chance LoC). Kennedy et al. (2001) suggest that people in the preparation SoC for physical activity tended towards more internal LoC which would appear to comply with the observation of increasing internal LoC score observed across ascending exercise behaviour change stages II-III in the present study. Investigating LoC and diabetes regimen concordance O’Hea et al. (2005) suggest internality is paramount in calculating health behaviours. In a later study O’Hea et al. (2009) suggested internal LoC is an important facet of diabetes management when interacting with self-efficacy and outcome expectancy constructs (O’Hea et al., 2009). Other research investigating internal LoC and diabetic health outcomes among type 1 and type 2 cohorts (Aikens
et al., 1994; Kneckt et al., 1999; Bunting and Coates, 2000) suggest there is no
relationship between the two. However these studies have targeted a single aspect of
regimen failing to consider the complexity of managing multiple self-management
behaviours simultaneously (Jones et al., 2003). Although causality can not be
confirmed in the present study exercise self-efficacy arising through performance
accomplishment and internal LoC resulting in individuals exerting greater effort
towards being sufficiently physically active for health benefits (Dzewaltowski et al.,
1990) are likely to be important antecedents for exercise behaviour change among
diabetes patients. This observation is supported by Plotnikoff and colleagues (2010a)
research investigating the ability of the TTM to predict physical activity stage
transition over a 6 month period among 1,157 patients with type 1 or type 2 diabetes.
Plotnikoff et al. (2010a) concluded targeting self-efficacy when promoting physical
activity among adults with diabetes, may favourably support stage transition in the
pre-action stages.

4.4.2 Co-morbidities
Diabetes patients have also previously identified co-morbidities as additional barriers
to self-care behaviour (Brown et al., 2002). The most commonly reported reason for
not exercising in the present study was the presence of other health problems which
made exercise difficult, reported by 35 (70%), 53 (40.5%) and 2 (6.9%) of the
participants in exercise behaviour change groups I, II and III respectively. For the
present study cohort, 10.0%, 13.7% and 24.1% of groups I, II and III respectively
reported no co-morbidities, 26.0%, 37.4% and 13.8% of the respective groups
reported having two co-morbidities, while 36.0%, 29.1% and 30.9% of the respective
groups reported having three or more co-morbidities. The number of co-morbidities
did not differ significantly between the three exercise behaviour change groups. The
relationship between self-efficacy, outcome expectations and functional status has
been investigated by Resnick (2002). Resnick (2002) suggests physical health, self-
efficacy and outcome expectations strongly influenced older people’s physical activity
choices and physical activity participation. In particular, Resnick (2002) found that
positive self-efficacy expressed through beliefs, positively influenced participant’s
motivation to walk. For instance, when participants believed they were incapable of
walking, they actively avoided and were reluctant to walk (Resnick, 2002). Despite
early equivocal evidence that outcome expectations are influential in the self-efficacy
model, there is now substantial research supporting self-efficacy as more motivational than outcome expectancies with respect to physical activity, particularly for older adults (Resnick, 2002). In addition, previous research suggests exercise behaviour correlates with self-efficacy levels and is particularly influential for exercise motivation (McAuley and Blissmer, 2000; McAuley et al., 2007). For the participants of the present study, it is possible that exercise self-efficacy may be the mediating factor in assisting individuals to overcome barriers and ascend the exercise behaviour change stages and increase their levels of physical activity or exercise. This proposal is supported by Thoolen et al. (2008) who suggests that it is the development of proactive skills and increase in self-efficacy that helps T2DM patients move beyond their good intentions towards performing self-management tasks.

While the presence of co-morbidities across the exercise behaviour change groups are comparable, it is interesting that 4 (13.8%) and 5 (17.2%) participants in exercise behaviour change group III, reported prior myocardial infarction and stroke, in comparison to 3 (6.0%) and 1 (2.0%) in group I, and 11 (8.4%) and 1 (0.8%) in group II. Investigating whether self-efficacy predicted physical activity in people following myocardial infarction, Luszcynska and Sutton (2006) found different forms of self-efficacy namely, ‘maintenance self-efficacy’ and ‘recovery self-efficacy’ predicted exercise continuation and physical activity in participants who relapsed. Investigating the role of LoC in recovery from myocardial infarction Cromwell et al. (1977) speculated that internals behave in a manner that does not aggravate their fragile conditions, showed greater cooperation and less depression, reflecting their more active participation. It is plausible that responses to life-endangering threats such as myocardial infarction may be at least partially determined by personality characteristics such as LoC (Lefcourt and Davidson-Katz, 1991). While the nature of higher levels of self-efficacy and internal LoC among patients in group III in comparison to their counterparts in groups I and II is not obvious, it is possible that those who have had an MI or stroke in group III have been exposed to greater volume of physical activity or exercise consultation and support through specific cardiac rehabilitation and from their healthcare team. Such exposure has been to shown to enhance self-efficacy to exercise, regulatory efficacy, exercise adherence and adjustment post cardiac event in a systematic review of self-efficacy for cardiac rehabilitation by Woodgate and Brawley (2008).
### 4.4.3 Physical activity and exercise advice

The level of physical activity or exercise advice reportedly received by participants varied significantly between the three exercise behaviour change groups. Among the exercise behaviour change groups, twelve (41%) participants in group III received three or four pieces of advice whereas only 4 (8%) and 21 (16%) participants in groups I and II respectively received three or four pieces of physical activity or exercise advice. To allow further investigation of this matter, the study cohort was stratified based on level of physical activity or exercise advice received into five groups ranging from 0-4, where 0 represented no advice and 4 represented the highest level of advice received. Significant between-group differences in relation to increasing levels of advice were observed for: physical activity (days·week⁻¹); structured exercise (days·week⁻¹); exercise self-management behaviour (days·week⁻¹); exercise behaviour change; self-efficacy to adhere to routine; self-efficacy to exercise; and, internal LoC. While significant between-group differences were observed throughout the categories from 0 to 4 pieces of advice, statistical analyses demonstrated significant differences were observed most frequently when participants received a total of 4 compared to 0, and 4 compared to 1 piece of physical activity or exercise advice from their healthcare team. This suggests increased physical activity or exercise advice reportedly provided by patients’ healthcare team was associated with the higher levels of exercise self-efficacy, internal LoC, and increased levels of physical activity and exercise behaviour. This observation is in contrast to that of Plotnikoff et al. (2010) who concluded that neither the quantity or quality of physical activity information provided by healthcare professionals predicted physical activity behaviour among a cohort of 244 patients with T2DM who participated in the aerobic and resistance training programme. However, while the present study’s assessment of physical activity or exercise advice by means of a numerical index is limited - failing to account for the quality of advice, and the value afforded by the patient to the source of advice - the method did present an avenue of exploration pertinent to promoting physical activity among free living T2DM populations outside an intervention context (Umpierre et al., 2011).

The potential effects of increased physical activity or exercise advice on physical activity, structured exercise, exercise self-management behaviour, exercise behaviour
change, self-efficacy to adhere to routine, self-efficacy to exercise, and, internal LoC may be explained through the mechanism of verbal persuasion (Bandura, 1986, 1997). Increases observed among these variables may be related to the impact of verbal persuasion and the appraisal an individual holds about their capability for a specific task. For instance, if there are self-doubts about their capabilities and a tendency to ruminate about personal deficiencies the persuasive efforts of a personal trainer or coach, in this instance a patient’s healthcare team, may counteract the self-doubt and rumination. Bandura (1986) argues verbal persuasion aimed at raising self-efficacy depends on the setting of realistic goals for effectiveness as unrealistic beliefs can reduce the persuader’s credibility to the hearer. Although the present study cannot account for goal-setting and persuader/healthcare professional’s credibility, it is plausible that like performance accomplishment, verbal persuasion may lead participants to perceive fewer barriers to physical activity (Bandura, 2001). The mechanism by which increased levels of physical activity or exercise advice could impact internal LoC is less obvious, but may be described in terms of increased internalisation of the behaviour. A possible explanation for this, beyond that posited in terms of increased self-efficacy, may be derived from Deci and Ryan (1985) who hypothesised that self-determination is principally controlled by the perception of choice to engage in behaviour. It is plausible that like individuals who participate in exercise classes, individuals in receipt of a greater variety and volume of physical activity or exercise advice, have greater perceived choice, and subsequently greater perceived autonomy and intrinsic motivation (Markland, 1999; Buckworth et al., 2007) similar to participants of the supported exercise programme discussed in Chapter 3.

Plotnikoff et al. (2010b) suggest T2DM patients receive physical activity orientated information from many different sources (including mass media and television), and the frequency of this is positively associated with both aerobic and resistance training behaviour in both cross-sectional and longitudinal models. However Plotnikoff et al. (2010b) also acknowledge that individual with T2DM report receiving less support, less education and less encouragement to undertake physical activity than any other area of diabetes management. In the present study, only 37 (18%) participants reported receiving 3 or 4 pieces of physical activity or exercise advice. A number of barriers to promoting physical activity in T2DM management have been reported by
healthcare professionals. These barriers include lack of specific knowledge and confidence for promoting and prescribing physical activity (Tudor-Locke et al., 1998), time (Kirk et al., 2004) and resources or comprehensive information (Stevenson et al., 2006). Furthermore, certified diabetes educators, often nurses and dieticians, have reported being poorly trained in physical activity related management for T2DM (Tudo-Locke et al., 1998; Bowman and Foster, 2007; Gornall et al., 2008) and resultanty are unable to provide more than just general physical activity guidelines. Considering these barriers in combination with the complex nature of managing T2DM where healthcare providers are also responsible for treating other risk factors, it is possible that healthcare providers are not adequately equipped to promote and support physical activity behaviour among their patients and merits further investigation.

In comparison to the self-management behaviours of medication adherence and blood glucose testing, reported levels of physical activity and exercise initially appear to be low. However, the ACSM and ADA joint position stand (Colberg et al., 2010) recommends physical activity should be distributed over a minimum of 3 non-consecutive days·week$^{-1}$. In the present study participants’ reported levels of self-management behaviour may reflect participant’s reaction to self-care guidelines. For example, participants would be directed to adhere to medication daily, whereas physical activity guidelines suggest activity should be performed 3-5 days·week$^{-1}$. In which instance the average activity levels reportedly achieved by the present study cohort are arguably close to published recommendations. According to the exercise behaviour change grouping, group I included 23.8% of participants who reported being in the contemplation stage – not physically active, 62.4% of the participants reported being at the preparation stage (group II) for physical activity behaviour, whilst only 13.8% of participants reported being in the active stage (group III). It is encouraging that on average participants of the present study report being close to achieving the lower limit for physical activity or exercise participation as outlined by the ACSM and ADA (Colberg et al., 2010) however, the present study also suggests that achievement of higher levels of physical activity or exercise could be effected by the level of physical activity or exercise advice received by patients from their healthcare team.
4.4.4 Limitations

As the study was cross-sectional, causality for any of the observed associations cannot be assumed. Physical activity or exercise levels are both an outcome and a determinant of health, and therefore is it acknowledged that longitudinal or intervention studies are required to investigate whether there is causality in the aforementioned associations. Further, observations in the present study, in particular between-group differences for exercise behaviour change and level of physical activity or exercise advice reportedly recieued were outcomes of an exploratory analysis. Given the exploratory nature of the present study, adjustment for multiple testing was not conducted (Bender and Lange, 2001). However, future confirmatory studies investigating the exploratory results of the present study that involve between group analyses will be be subject to multiple test adjustment. Self-reporting of self-management behaviours and in particular physical activity and exercise must be considered with caution. For instance individuals who report they are close to the lower limit of physical activity guidelines may actually reflect what they think they should be doing, but not what they achieve in reality. Subject biases such as social desirability bias (the propensity to report behaviour that is compatible with social norms) or demand characteristics may also affect self-reporting of behaviours, completion of self-efficacy and LoC scales, and physical activity or exercise advice reportedly received in the present study. A limitation of the present study, as observed in previous studies, is the use of HbA1c as the sole measure of treatment concordance. The present study does however acknowledge the complexity of physical activity and exercise investigating the behaviour in the context of other self-management behaviours and not in isolation. It is accepted that the use of HbA1c as a sole measure of concordance may not be sufficient and other measures important in diabetes management and development of complications, such as lipid profiles should also be used as a marker of diabetes management as suggested in Chapter 3. Assessment of current or baseline physical activity levels using the SoC model has been advocated previously by Marcus et al. (1998), Kirk et al. (2001; 2004; 2007) and Woods et al. (2002). However, Adams and White (2005), and Bridle (2005) argue the SoC model for physical activity oversimplifies what is a complex behaviour and restricts people to meeting a defined physical activity criterion. This issue may have been augmented by collapsing of the five SoC stages into three exercise behaviour change groups. However, this step was taken in the context of an exploratory approach to analysing
the data set with the purpose of discovering novel factors which may be associated with sedentary behaviour, initiation, and maintenance of physical activity behaviour among individuals with T2DM. Collapsing of SoC assisted the exploratory approach through the formation of three distinct activity groupings (I-inactive [precontemplators/contemplators], II-active but not meeting recommendations [preparation], III-regularly active [action/maintenance]) as well as assist with conducting more robust between-group statistical analysis by increasing group sample size. Diabetes management in Northern Ireland utilises a shared-care approach where the heterogeneous nature of T2DM is dealt with at both GP surgeries and hospital based clinics alike. Participant recruitment in the present study was conducted entirely in a hospital setting and despite the nature of care in Northern Ireland it is acknowledged that physical activity studies conducted in such a setting may be exposed to recruitment bias towards participants being less active and having more health problems. However, this bias could prove advantageous for physical activity intervention studies for individuals with T2DM, especially when targeting an inactive sample or those with health problems with most to gain from increased physical activity behaviour and not just those who are motivated to volunteer.

4.4.5 Conclusion

While limitations of the present study are acknowledged, the novelty and strength of the present study lies in its approach to investigating physical activity behaviour not in isolation but within the context of other self-management behaviours. The study utilised psychosocial theories and supporting instruments and measures with the goal of investigating motivation towards physical activity behaviour whilst also assessing other self-management behaviours and motivations which potentially vie with one another. The study also attempted to explore both internal and external barriers and facilitators by exploring how factors such as co-morbidities and significant others such as family and healthcare providers may influence motivation and behaviour among individuals with T2DM. In the present study, patients with T2DM were on average close to achieving the lower limit for physical activity or exercise participation as recommended by the ACSM and ADA joint position stand (Colberg et al., 2010). It would also appear that higher levels of physical activity or exercise can and should be achieved by this population. Although associations observed in the present study should be treated with caution, significant between-group differences
based on a collapsed stages of change model (exercise behaviour change) suggests exercise self-efficacy, internal LoC and the level of physical activity or exercise advice afforded to patients by their healthcare team could be mediating factors in assisting patients to progress across stages of exercise behaviour change towards increased physical activity and exercise levels. Further longitudinal or intervention based research investigating these potential mediators with subsequent confirmatory analysis is required. It is also possible that increased physical activity or exercise advice assisting patients to increase these behaviour levels may be comparable to improvements observed in Chapter 3 among unsupported (control) group participants at an individual level and at one year follow-up. Increased advice may affect patients in the same way minimal intervention contact (e.g., brief advice, standardised print materials) can affect control group participants in physical activity intervention trials. As brief interventions that result in increases in physical activity are likely to be highly cost-effective, determining whether increased physical activity and exercise advice in terms of both quality and quantity from healthcare providers can lead to improvements in physical activity levels and individual characteristics such as HbA$_1c$ and lipid levels among those with T2DM merits further investigation and could have important implications for how healthcare providers promote physical activity within diabetes management.
Chapter 5

Understanding physical activity self-management behaviour among patients with type 2 diabetes mellitus: A qualitative study
5.1 Introduction
The following chapter reports a qualitative study exploring T2DM patients’ perception of physical activity in their self-management, detailing the methods used, study results, followed by discussion of the findings, and their implications for future research and practice.

5.1.1 Overview
Diabetes self-management focuses on improving glycaemic control through adherence to treatment regimen; medication adherence, blood glucose testing, regulating dietary intake and increasing physical activity (Whittemore et al., 2005). Physical activity is a fundamental management strategy for people with T2DM, however, promoting physical activity, remains one of the greatest challenges in the management of T2DM, as evidenced by low prevalence estimates (Plotnikoff et al., 2011a). Whether low prevalence of physical activity behaviour is related to lack of knowledge, support, or encouragement to undertake physical activity is not fully understood (Kirk et al., 2007).

Studies have examined facilitators (Van Rooijen et al., 2002; Donahue et al., 2006; Mier et al., 2007; Ferrand et al., 2008) and barriers (Dye et al., 2003; Thomas et al., 2004; White et al., 2007) for regular physical activity among individuals with T2DM. Van Rooijen et al. (2002) have presented better health, quality of life, better glucose control and fun as facilitators for exercise. Donahue et al. (2006) suggest the facilitators for exercising were high priority and self-efficacy related to physical activity, beliefs regarding weight control through activity, receiving social support, and having enough time for physical activity. Mier et al. (2007) suggest well-being, looking better and family support are important facilitating factors. Ferrand et al. (2008) presented social and psychological facilitators for regular physical activity and also highlighted gender differences in adults with T2DM. For example, female participants emphasised the importance of emotional support, pleasure of doing something together, sense of well-being and positive body image. For male participants, facilitators for regular exercise were knowledge acquisition and skill development for disease control, and strength of the relationship between physical activity and health-promoting effects (Ferrand et al., 2008).
The most commonly reported barriers to regular physical activity among individuals with diabetes are physical limitations/poor health, being overweight, lack of time, unwillingness to participate in physical activity and lack of facilities (Van Roijen et al., 2002; Donahue et al., 2006; Mier et al., 2007; Ferrand et al., 2008). A systematic review by Korkiakangas et al. (2009) investigating barriers to regular exercise among adults at high risk or diagnosed with T2DM identified two kinds of barriers to regular exercise: internal and external. Korkiakangas et al. (2009) described internal barriers as factors which were influenced by the individual’s own decision-making leading individuals to feel that the reasons for exercising including goals and benefits of exercise were insufficient compared to the costs of exercising (for example pain, tiredness, feeling that exercise is uncomfortable and negative emotions). External barriers, as described by Korkiakangas et al. (2009), included factors distinct from an individual’s inner decision-making, which prevented exercising through barriers such as the lack of exercise facilities, lack of social support and difficult life situations – commonly, lack of time due to work or home duties.

Korkiakangas et al. (2009) suggest external barriers can be overcome through for instance, increasing public knowledge of different facilities for exercise and by further developing the facilities. Although the authors suggest it is the internal barriers that demand greater attention, given the apparent dynamic between some internal and external barriers such as being overweight and appropriate facilities, focusing attention on an internal barrier such as being overweight, may be counterproductive. For example, focusing on an individual’s perception that they are overweight, will not necessarily help that person to overcome the emotional issues associated with this internal barrier nor will simply providing a facility to exercise. Korkiakangas and colleagues’ (2009) systematic review suggests that information about the importance of physical activity is rarely sufficient to motivate a sedentary adult to exercise. However, the authors also suggest comprehensive information promoting physical activity behaviour is not widely available to individuals with T2DM supported by Plotnikoff et al. (2010b). While reviews such as that undertaken by Korkiakangas et al. (2009) help to compile and group an array of barriers and facilitators, it is possible that creating such lists oversimplifies a complex behaviour and fails to fully acknowledge how these factors impact diabetic individual’s motivation for physical activity. Further, by focusing solely on physical activity behaviour, studies and
reviews sometimes neglect the difficulties faced by T2DM patients who must motivate themselves to initiate and maintain physical activity while also simultaneously managing multiple self-care behaviours (Jones et al., 2003).

Given the complex nature of diabetes self-care and suggestions that up to 70% of patients with T2DM fail to achieve the recommended level of physical activity (Plotnikoff et al., 2011a) the one-dimensional approach of simply reporting internal and external barriers to physical activity is unlikely to lessen the burden of sedentary behaviour among T2DM patients. Sallis and Owen (1999) suggest that models often posit multiple levels of influence on behaviour and include, for example, factors at the personal level preventing people from being physically active (e.g. lack of time), barriers at the social level (e.g. family and work demands), and barriers at the environmental level (e.g. poor access to physical activity facilities).

To consider physical activity in the context of other self-care behaviours as well as from the perspective of different models and theories acknowledges the intricacy of cognitive processes behind behaviour and may deepen our understanding of how internal and external factors affect motivation and subsequent behavioural outcomes. In considering the multiple levels of influence which models and theories can encompass (Sallis and Owen, 1999), the SDT (Deci and Ryan, 1985; 2000) described in detail in Chapter 2, offers considerable appeal. The SDT posits human beings have a natural tendency to internalise and integrate behaviour and activities into a coherent sense of self (intrapersonal) which is contingent upon environmental (interpersonal or structural) factors that either facilitate or impede this process. Ryan and Deci (2002) suggest environmental conditions that stimulate optimal psychological growth and development namely the need to feel autonomous, competent, and related to others are hypothesized to foster more autonomous or intrinsically motivated behavioural regulations. Environmental factors that fail to satisfy these psychological needs promote less internalised, more extrinsically controlled types of behaviour regulation where people feel pressured to participate in an activity, and therefore experience little self-determination or autonomy (Ryan and Deci, 2002). For example, information where performance rather than task enjoyment and learning are the focus or where healthcare professionals are perceived to be controlling as opposed to autonomy
supportive may undermine intrinsic motivation to initiate and maintain physical activity behaviour (Ryan et al., 2008).

Healthcare climates or environments which use positive feedback and verbal persuasion, and attempt to provide choice and agency (autonomy), have been shown to enhance self-efficacy (Wise and Trunnell, 2001; Morris and Koehn, 2004) and strengthen identified regulation, intrinsic motivation and autonomy (Pelletier et al., 2001). Williams et al. (1998b) have suggested that patients who are exposed to SDT motivational approaches to diabetes treatment are more likely to adhere to medication regimen if they perceive their healthcare provider to be understanding of their perspective, acknowledging of their feelings, and offers treatment choices. Further research undertaken by Williams and colleagues has also suggested higher levels of perceived autonomy support have been linked to greater self-determined motivation as well as attainment of health related goals that include improved glycaemic control in patients with diabetes (Williams et al., 2004; 2005a), diet and exercise adherence in patients with or at risk of coronary artery disease (Williams et al., 2005b), and greater success in smoking cessation (Williams et al., 2006).

There is a growing body of research in exercise psychology that provides evidence highlighting the value of SDT as a comprehensive motivational framework for understanding physical activity behaviour. Research based on SDT has demonstrated that psychological need satisfaction is positively related to physical activity self-determined motivation and self-determined motivation has been found to be positively associated with self-reported exercise behaviour and higher physical activity participation (Wilson et al., 2003; Wilson and Rodgers, 2004; Edmunds et al., 2006). Despite rising popularity of studies designed around SDT in the exercise domain (Wilson et al., 2008), there is a paucity of research employing the self-determination perspective to study physical activity and exercise behaviour among individuals with T2DM. While the aforementioned studies support the main tenets of SDT, there is a need to: 1) identify factors which facilitate or impede physical activity behaviour and, 2) describe how these underlying factors influence the satisfaction of the basic psychological needs and self-determined motivation for physical activity among individuals with T2DM.
5.1.2 Study objectives

5.1.2.1 General objective
To explore, compare, and contrast participants' perception and use of physical activity as a self-management behaviour among a group of patients who participated in an exercise intervention following diagnosis of T2DM approximately 4 years earlier (as described in Chapter 3), and a group of patients who received standard care following diagnosis.

5.1.2.2 Specific objectives
(1) To identify potential barriers and facilitators to physical activity as a self-management behaviour.

(2) To discuss emergent barriers and facilitators within the context of the SDT.

5.2 Methods
Qualitative research methods were used to fulfil the planned objectives initially through the use of semi-structured interviews and thematic data analysis to identify emergent themes and sub-themes representing factors which may facilitate or impede physical activity behaviour. Subsequently, the emergent themes and sub-themes, representing barriers and facilitators to physical activity behaviour among individuals with T2DM, were discussed in light of a framework of predefined SDT constructs.

5.2.1 Participants
Recruitment was undertaken from December 2009 to July 2010. Inclusion criteria included participants with T2DM only, male or female, inclusive of all age’s ≥18 years, be able to provide written informed consent, and English speaking.

A total of twenty-one participants representing two groups, Group 1 - participants who had been received a 12-week exercise intervention upon initial diagnosis of their diabetes (as described in Chapter 3), and Group 2 - participants who had received only standard care following diagnosis (previously recruited to a cross-sectional questionnaire study described in Chapter 4) completed a semi-structured interview.
The study protocol was approved by the University of Wales Institute Cardiff Ethics Committee, the Western Health and Social Care Trust Research Governance Committee and the Office for Research Ethics Committees Northern Ireland. All participants received written and verbal information regarding the nature of the study in the form of Information Sheet (Appendix 10) and were required to provide a signature of consent (Appendix 11) - evidence the participants had made a choice to take part in the study, free from unfair inducement or manipulation.

5.2.2 Development of interview schedule

The aim of the semi-structured interviews was to encourage participants to express their views on physical activity as part of their diabetes self-management and discuss factors they perceived to be barriers and facilitators to physical activity behaviour. The interview schedules for Group 1 and Group 2 are summarised in Table 5.1. Complete interview schedules are included in Appendices 12 and 13. The interview schedules outlined in Table 5.1 included several areas of interest. The opening questions addressed self-management behaviour encouraging participants to discuss their overall self-care activities including, adherence to prescribed pharmaceutical treatment (if appropriate), blood glucose testing and dietary behaviour. The schedule used for participants of Group 1 also included additional questions concerned with participation in the exercise intervention described in Chapter 3.

Interview schedules for both Group 1 and 2 included questions directed at the following areas: physical activity behaviour; confidence in ability to manage diabetes; and, perceived responsibility for diabetes management. Participant’s physical activity behaviour was explored in terms of their physical activity history, current level of behaviour in relation to stages of change (SoC) as well as frequency, intensity, duration and type and the perceived impact of living with diabetes on their physical activity/exercise behaviour. Current physical activity levels were assessed using the SoC for physical activity behaviour scale (Marcus et al., 1992). The following physical activity recommendation was read to participants: “30 minutes of moderate intensity physical activity 5 days·week$^{-1}$ or 3-5 days·week$^{-1}$ of vigorous intensity activity for 20 minutes”. Participants were then asked to indicate which of the five stages best described their current activity level in relation to the recommendation: precontemplation (not physically active or intending to be within the next 6 months),
contemplation (not physically active but considering becoming active within the next 6 months), preparation (doing some physical activity but not enough to meet physical activity guidelines), action (regularly physically active but for less than 6 months) or maintenance (regularly physically active and for more than 6 months).

The areas of interest were generated in follow-up to studies undertaken in Chapters 3 and 4. In the Group 1 schedule probing questions concerning reasons for volunteering for the exercise intervention, experience on programme, and programme impact on diabetes management focused specifically on the experience of individuals who participated in the exercise programme described in Chapter 3. Similarly, questions which focused on confidence in ability to manage diabetes and perceived responsibility for diabetes management sought to investigate further aspects of self-efficacy and LoC which were examined within the cross-sectional study described in Chapter 4.

Table 5.1 Summary of interview schedules including main themes and probes

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Group 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introductory diabetes self-management questions</td>
<td>Introductory diabetes self-management questions</td>
</tr>
<tr>
<td>Exercise intervention</td>
<td></td>
</tr>
<tr>
<td>- reasons for volunteering</td>
<td></td>
</tr>
<tr>
<td>- experience on programme</td>
<td></td>
</tr>
<tr>
<td>- impact on management</td>
<td></td>
</tr>
<tr>
<td>Physical activity/exercise behaviour</td>
<td>Physical activity/exercise behaviour</td>
</tr>
<tr>
<td>- prior physical activity history</td>
<td>- prior physical activity history</td>
</tr>
<tr>
<td>- stages of change for physical activity behaviour</td>
<td>- stages of change for physical activity behaviour</td>
</tr>
<tr>
<td>- impact of diabetes</td>
<td>- impact of diabetes</td>
</tr>
<tr>
<td>Confidence and your diabetes management</td>
<td>Confidence and your diabetes management</td>
</tr>
<tr>
<td>- confident in your ability to manage diabetes</td>
<td>- confident in your ability to manage diabetes</td>
</tr>
<tr>
<td>- confident about physical activity</td>
<td>- confident about physical activity</td>
</tr>
<tr>
<td>Responsibility for diabetes management</td>
<td>Responsibility for diabetes management</td>
</tr>
<tr>
<td>- taking the lead</td>
<td>- taking the lead</td>
</tr>
<tr>
<td>- well managed and less well managed</td>
<td>- well managed and less well managed</td>
</tr>
<tr>
<td>Responsibility for physical activity</td>
<td>Responsibility for physical activity</td>
</tr>
<tr>
<td>- personal</td>
<td>- personal</td>
</tr>
<tr>
<td>- family and friends</td>
<td>- family and friends</td>
</tr>
<tr>
<td>- healthcare team</td>
<td>- healthcare team</td>
</tr>
</tbody>
</table>

The inclusion of questions relating to self-efficacy (confidence) and LoC (responsibility) in schedule development indirectly provided the opportunity for
participants to discuss their physical activity behaviour in the context of potential intrinsic and extrinsic facilitators and barriers. The schedules focused on participant’s perception and use of physical activity to self-manage their condition and what they perceived to be factors which supported or impeded their ability to perform the behaviour. Further, the questions explored physical activity as self-management behaviour within a holistic diabetes management context, providing participants the opportunity to discuss their overall self-management activities, rather than discussing physical activity in isolation.

5.2.2.1 Pilot interview
Two practice interviews lasting 18 and 24 minutes respectively were completed prior to commencing data collection. The practice interviewees were a nurse with research and clinical experience in diabetes care and a patient with T2DM. The pilot interviews provided the opportunity for the researcher; to test questions, focusing in particular on the continuity and flow of probing questions, assess perceived data saturation and to practice interview technique.

5.2.3 Data collection
An individual interview method was selected rather than focus group discussion in an attempt to gain an understanding of the range of perspectives on physical activity behaviour. Focus group discussions can move toward consensus (Kitzinger, 1996) therefore, to encourage exploration of individual and personal attitudes and perceptions, one-to-one interviews were deemed more appropriate. A semi-structured approach was adopted for the interviews (Merton et al., 1990). Accordingly, interviewees were encouraged to speak honestly and as freely as possible as to their experiences and perceptions of physical activity in diabetes self-management whilst elaborating upon the context of their experiences. An important aspect of the interviews in terms of credibility was to ensure honesty among participant’s discussion. To assist this all individuals were given the opportunity to refuse to participate to ensure only those who were genuinely willing to take part and prepared to offer data freely were included in the study. Further, the researcher aimed to establish a rapport with the participants from the outset and in the moments leading to the interview the researcher indicated there were no right or wrong answers to the questions that would be asked and participants were encouraged to be frank
throughout the interview. The independent status of the interviewee was also established from the onset to ensure participants could contribute ideas and discussion without fear of recrimination from their healthcare team or provider.

The interviews took place at a location convenient to the interviewee or via telephone. Although a number of challenges to conducting telephone interviews could arise, such as difficulty in building a rapport, the benefits of the method including, reduced forms of response bias (Marcus and Crane, 1986), the anonymity associated with telephone contact in enabling participants to be open and forthcoming with responses (Sturges and Hanrahan, 2004), and increased level of comfort for both the interviewee and interviewer leading to a more relaxed interview (Smith, 2005) had been previously recognised. Other challenges common to both telephone and face-to-face interviews including; maintaining participant involvement, maintaining clear communication, communication with participants who offer extraneous information, and encountering participants with health concerns were acknowledged (Musselwhite et al., 2006). The occurrence of potential challenges was limited by all interviews being undertaken by the same researcher to ensure consistency and the researcher adhering to the same procedures for both the telephone and face-to-face interviews. The possibility of self-report methods such as those observed in semi-structured interviews via telephone or face-to-face being subject to biases such as over reporting was also acknowledged. However, as with all self-report methods there was a dependency on interviewee honesty. Validity and reliability of the interviews were further supported by the researcher adhering to the same interview structure and schedule for participants of each group, as well as continuation of each interview until point of data saturation and emergence of recurrent themes. All interviews were audio recorded and ranged in duration from 15 to 50 minutes reflecting the wide variation in how communicative the interviewees were. The decision to discontinue conducting interviews with further participants occurred when no new information was being observed in the overall data set.

5.2.4 Qualitative analysis

Group and interviewee labels were applied as the data was collected distinguishing the participants. All the interviews were recorded and transcribed verbatim. A copy of the audio-recordings and transcripts were independently checked for accuracy by an
experienced qualitative researcher (JS). A thematic analysis of the data using a multistage approach summarised in Table 5.2 (adapted from Braun and Clarke, 2006) was performed. The thematic analysis, essentially independent of theory and epistemology, acted as a flexible research tool, with the potential to provide an original, rich, and detailed account of data.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Description of the process</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Familiarising oneself with the data:</td>
<td>Transcribing data, reading and re-reading the data, noting down initial ideas.</td>
</tr>
<tr>
<td>2. Generating initial labels:</td>
<td>Labelling interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code.</td>
</tr>
<tr>
<td>3. Searching for themes:</td>
<td>Collating labels into potential themes, gathering all data relevant to each potential theme.</td>
</tr>
<tr>
<td>4. Reviewing themes:</td>
<td>Checking if the themes work in relation to the coded extracts (Level 1) and the entire data set (Level 2), generating a thematic ‘map’ of the analysis.</td>
</tr>
<tr>
<td>5. Defining and naming themes:</td>
<td>Ongoing analysis to refine the specifics of each theme, and the overall story the analysis tells, generating clear definitions and names for each theme.</td>
</tr>
<tr>
<td>6. Producing the report:</td>
<td>Selection of vivid, multiple prevalence, compelling extract examples. Final analysis of selected extracts, relating back to the analysis and the research question and literature, producing a scholarly report of the analysis.</td>
</tr>
</tbody>
</table>

(Adapted from Braun and Clarke, 2006)

Phase 1 of the thematic analysis commenced during data collection and subsequently whilst the researcher was transcribing the recordings. The researcher read through all the data collected repeatedly to become familiar with the data set. In Phase 2 through an iterative process, labels were generated across the data set and relevant data were collated. Initial emergence of labels is illustrated in Figures 5.1 and 5.2 for Groups 1 and 2 respectively.

After labelling and collating the data, analysis progressed to Phase 3 where the researcher re-focused at the broader level of themes, rather than labels. This involved sorting the different items into potential themes, and collating all the relevant labelled data extracts to form overarching candidate themes and sub-themes. Themes were acknowledged to represent something important about the data in relation to the
research objectives – how did participants perceive physical activity within their diabetes self-management regimen and perceived barriers and facilitators for the behaviour.

![Initial thematic map for Group 1 showing emergent labels](image1)

![Initial thematic map for Group 2 showing emergent labels](image2)

The thematic analysis allowed the researcher to determine themes through the number of different interviewees who articulated the theme, across the entire data set. However, themes were not restricted to ‘prevalence’ alone as it was also
acknowledged that a theme could emerge where it had been given considerable space in some data items by an interviewee, and little or none by others interviewees. In support of this approach, Braun and Clarke (2006) suggest there is no right or wrong way to determine emergence and prevalence of themes, but emphasise a need for some flexibility, suggesting rigid rules are ineffective. Collation of labelled items and emergent candidate themes from Phase 3 of the thematic analysis are illustrated in Figures 5.3 and 5.4 for Groups 1 and 2 respectively.

Figure 5.3 Developed thematic map for Group 1 showing collation of labelled items into potential themes and sub-themes
Phase 4 involved the refinement of candidate themes emergent in Phase 3. This phase of data analysis identified whether candidate themes had enough data to support them, or the data contained with the theme was too diverse. This provided the opportunity for the researcher to collapse themes into each other or break down themes into separate themes or sub-themes. The researcher was responsible for ensuring the data within the themes cohered meaningfully, and clear and identifiable distinctions between themes were also evident.

In Phase 5 the researcher defined and refined themes. During this phase of analysis it was necessary to identify what each theme was about and determine what aspect of the data each theme captured. It was important that the themes did not try to do too much, or be too diverse and complex. Rather, the researcher considered whether each theme told a story, whether there was limited overlap between themes, and, how each theme fitted into the broader overall story about the interview data, in relation to the research objectives. During this phase it was also imperative that each theme could be clearly defined and the scope and content of each theme could be described by the researcher in just a few sentences. Further, up until this point the themes had working titles, but for the purpose of the final report the themes and sub-themes were given names considered to be more concise and capable of immediately giving the reader a
sense of what the theme was about. The final themes and sub-themes are illustrated in Figures 5.5 and 5.6 for Groups 1 and 2 respectively.

Although there were no clear rules in the current thematic analysis, to ensure credibility it was important that the researcher was consistent in how the analysis was performed. The credibility and trustworthiness of the analysis was further strengthened by JS who independently corroborated the interview transcripts to ensure emergent themes and sub-themes accurately reflected participant’s perceptions. First, JS independently reviewed the transcripts and subsequently labelled items identified as meaningful descriptions or noteworthy statements related to the research objectives. JS then independently collated the labelled items to derive potential themes and sub-themes. Subsequently, the researcher and JS met to compare preliminary findings and discuss interpretations before the main themes and sub-themes were derived.

Phase 6 the thematic analysis, the report, is embodied within Sections 5.3 and 5.4 and contains a summary of the emergent themes and sub-themes for each of the two groups (Section 5.3, Figures 5.5 and 5.6). The themes and sub-themes that emerged from the data, reflecting participant’s perception of physical activity and their perceived barriers and facilitators to the behaviour, are discussed in Section 5.4.1. Subsequently, using the SDT as a framework, meaning was assigned to the themes and sub-themes and their interpretation presented in Section 5.4.2 (Tables 5.3. and 5.4).

5.3 Results of semi-structured interviews

Interviews were completed and transcripts produced for twenty-one participants.

5.3.1 Group 1

Figure 5.5 illustrates the themes and sub-themes relating to participants’ perception and use of physical activity in their diabetes self-management for Group 1. The emergent themes include: 1) behaviour initiation, 2) learning through doing, 3) peer support and, 4) belief.
The themes ‘behaviour initiation’, ‘learning through doing’, and ‘peer support’ which emerged following Group 1 interviews, related to the exercise programme described in Chapter 3. Within the theme ‘behaviour initiation’ there were two sub-themes, ‘response to diagnosis’ and ‘lending a hand’ - a desire on the behalf of participants to assist research and the wider diabetic community. In the context of physical activity as self-management behaviour, the theme ‘belief’ also emerged as a recurrent and dominant theme.

5.3.2 Group 2

Table 5.4 presents the themes and sub-themes relating to participants’ perception and use of physical activity in their diabetes self-management for Group 2. The emergent themes differed from those observed in Group 1, and included: 1) barriers to physical activity, 2) why physical activity (PA), 3) awareness and, 4) perceived support.
The themes and sub-themes to emerge from Group 2 - interviewees who did not previously participate in the exercise study described in Chapter 3 - predominantly reflecting perceived barriers and facilitators to physical activity as a self-management behaviour.

5.4 Discussion

The present study explored the perception and use of physical activity as a self-management behaviour among patients with T2DM. The participants comprised two distinct groups, patients who participated in an exercise programme intervention following initial diagnosis (Group 1) and patients who received standard care following diagnosis (Group 2). The following discussion describes emergent themes and sub-themes from semi-structured interviews representative of barriers and facilitators to initiating and maintaining physical activity behaviour using quotes from interviewees which are identified by group and participant number (e.g. Group 1 participant 8, is 1.8). Subsequently, and where appropriate, the emergent themes and sub-themes are aligned with and discussed in light of constructs of the SDT.

5.4.1 Barriers and facilitators to physical activity

5.4.1.1 Group 1

The theme ‘behaviour initiation’ in reference to the exercise programme described in Chapter 3 suggests that among the participants of Group 1, the availability of a programme following initial diagnosis of diabetes prompted physical activity behaviour through two principle reasons. These reasons were evident within the sub-themes: ‘response to diagnosis’ and a desire on the behalf of participants to assist research and the wider diabetic community (‘lending a hand’).

‘Response to diagnosis’ suggested more than half the participants of Group 1 viewed the exercise programme as an opportunity to become physically active, helping motivate participants to initiate and maintain the behaviour.

“I think it was a kick up the backside really to sort of ah to do that… ...a sort of motivator... ...it would do me good and maybe sort of push me into a better lifestyle... ...I think that was the main reason” (1.8)

“I did want to do something and I knew I had to do something, and it was a way of making a start, you see once you make that start it’s easier to continue... ” (1.9)
‘Response to diagnosis’ also suggested that a prerequisite to volunteering for the exercise programme - evidence of willingness to initiate physical activity - was the view that physical activity could potentially benefit a participant on an individual level.

“I thought well I’ve got it, so let’s do something positive about it” (1.1)

“I was so grateful to be offered something like that...” (1.4)

“I was delighted when it came through, y’know there’s a certain shock and you don’t quite know how to cope with it” (1.5)

In contrast to ‘response to diagnosis’, the sub-theme of ‘lending a hand’ again discussed by half of the Group 1 cohort, suggested that among the volunteers a disposition to consider the good of others (altruism) and help with research was also an important factor in motivating participants to join the exercise programme.

“...and it may not help me but it certainly may help somebody in the future” (1.1)

“I think if people are taking the time, then people should take the time to help well try and help beat it sort of thing” (1.3)

“I was very pleased that anybody was doing the research into it and wanted to help in any way at all” (1.4)

“Well, I’m quite in favour of doing anything I can to help medical research really. My contribution enables for a possible cure for diabetes or best treatment in the future so I’m more than happy to take part in that” (1.10)

In combination both ‘response to diagnosis’ and ‘lending a hand’ as facilitators may reflect be indicative of a window of opportunity to engage newly diagnosed T2DM patients in an exercise programme – a suggestion which requires further research. The two sub-themes representing the majority of Group 1 participants, may also suggest this particular cohort were already highly motivated and willing volunteers for the exercise programme. This proposition is discussed later in relation to SDT.

The semi-structured interviews moved on to discussion of interviewee’s perception of the exercise programme and their current physical activity levels. A widely held view among Group 1 participants, which led to the emergence of the sub-theme ‘learning through doing’, was the nature of the exercise programme was conducive to learning about physical activity and improving their confidence in using physical activity to manage their diabetes. Participants articulated a number of facilitating mechanisms within the theme, including, safety, support, and enjoyment.
“...I just think that [with] controlled exercise... I was feeling quite safe about exerting myself slightly...... showed that things worked and went the right way” (1.2)

“...I enjoyed it, it was great, and...I felt better for [it], but the main thing was I was enjoying it, it wasn’t a chore.... I think again, it was speaking to the other people and the environment where you were being helped” (1.9)

Interviewees also suggested that the exercise programme affected their longer term self-management behaviour by helping individuals to sustain their increased level of physical activity at programme completion, through improved discipline...

” they became a focus for me, the exercise programme and a pattern that I haven’t forgotten and haven’t let go of... ...and totally committed to that, that system now, after my experience” (1.4)

“I don’t think I would have been so disciplined and confident in my management of it if I had not had the programme” (1.5)

... confidence...

“I wasn’t really managing it. I was just letting it carry on, and people were telling me, you shouldn’t eat this, you shouldn’t eat that, whereas after the programme, I was managing it better myself” (1.9)

... and understanding of the effects of physical activity on their condition and overall health.

”I learned a lot from speaking to the other people there, but also from the programme because I have kept an exercise regime up” (1.9)

”It’s not just the diabetes, I’m aware that as I get older, I want to keep my body healthy as long as I can, and through physical exercise I’m helping that really” (1.10)

”I was very grateful for that, because it gave me complete understanding of the condition, and what to do about it” (1.11)

The factors evident within ‘learning through doing’, in particular growing confidence are consistent with findings that suggests situations or environments which use positive feedback and verbal persuasion enhance self-efficacy and self-care behaviours (Wise and Trunnell, 2001; Morris and Koehn, 2004; Williams et al., 2004). The value of enhanced self-efficacy and physical activity self-management behaviour are is supported by Donahue et al. (2006) who suggests self-efficacy related to physical activity is a vital facilitator for continuation and maintenance of the behaviour.

The overarching theme of ‘peer support’ emerged as participants described their commitment to and enjoyment of the exercise programme. Illustrated within the
theme were sub-themes, ‘encouragement’ and ‘dependency’. Half of the Group 1 participants described how the programme facilitated increased physical activity through the positive impact of group participation, ‘encouragement’.

“...we were a good bunch of people... ...thoroughly enjoyed it” (1.2)

“I got a tremendous amount of support from the programme” (1.4)

“I thoroughly enjoyed it, it was good, it...ah...it...ah, it felt really oh, the positive influence of sharing something with, with people like that, you know the influence of a team, almost” (1.5)

The group setting offered participants the opportunity to share and discuss problems as well as create an environment of healthy competition whereby individuals managing the same condition could urge one another forward.

“... everyone spurred each other on and ah, well you’ve all sort of got a cause haven’t you? And it worked, it seemed to work for the others as well I thought...” (1.8)

“ It was nice meeting with other people who had the same problems, because you don’t usually meet them, other than in clinics so I enjoyed that as well” (1.9)

As previously acknowledged by Donahue et al. (2006), it is evident that the group environment offered by the exercise programme provided social support for participants. The value of social support is also supported by Albarran et al. (2006) who suggests participants value the importance of the emotional support obtained from group meetings and the pleasure of doing something alongside their peers.

The value of ‘peer support’ is further demonstrated by the sub-theme of ‘dependency’. Interestingly, only four participants contributed to this sub-theme, all of whom also contributed to ‘encouragement’. Similarly to potential of ‘peer support’ to facilitate initiation and maintenance of physical activity, ‘dependency’ suggests that some T2DM patient’s value, benefit from, and potentially need the company of their peers in an exercise environment.

“I missed it when I finished” (1.2)

“I missed the support of the group... ...I just didn’t sort of connect with the sort of personal trainer information that I was given... ... you need to be supported and you need to do it in a group...” (1.4)

“but the downside is without the motivation around me I found it very hard to keep up that level of exercise” (1.8)

“I don’t mean anything as near as hard as that was, but I have kept up exercise” (1.9)
It is possible that for some individuals with T2DM, the company and support of peers may help them to overcome initial barriers to exercise behaviour particularly in the period immediately after diagnosis.

In a similar context, but in contrast to the benefits provided by a supportive environment, ‘dependency’ may also reflect the risk of a short-term exercise programme to unintentionally create a barrier to future physical activity behaviour among some participants. While this observation may be limited to just half the participants of Group 1, it may indicate a need for ongoing behaviour reinforcement and support for patients with T2DM. Given that so many individuals with T2DM do not achieve the recommended level of physical activity (Plotnikoff et al., 2011a) the observation may be true for many individuals across the wider diabetic population. A similar finding has been observed recently by Casey et al. (2010). Following a supervised exercise programme, individuals with diabetes were unable to maintain physical activity levels achieved during the programme when support was discontinued (Casey et al., 2010). Although the Casey and colleagues study is also limited by its small sample size (n=16) the study suggests it is the coming together of participants and the sharing of similar circumstances which appears to be imperative to increasing physical activity levels among diabetic individuals. The current observation along with those of Casey et al. (2010) are in contrast to the suggestion that it is healthcare professionals who play an important role in maintaining and changing physical activity behaviours among their patients (McKenna and Vernon, 2004; Tullock et al., 2006). Including other people in one’s situation (in this instance exercising with peers while dealing with their diabetes diagnosis) may be a necessary antecedent and facilitator for active steps towards coping with diabetes and adaptive self-management behaviour as suggested by Delmar et al. (2006).

Although it is not clear whether participants held strong views about physical activity prior to commencing the exercise programme, the theme of ‘belief’ suggested the majority of participant’s in Group 1 believed physical activity can benefit their diabetes and overall physical health.

“it’s a fact that if you exercise and diet control... you can hold back the diabetes” (1.2)
“...it was quite obvious there were benefits to be gained... ...it could well be the reason why it’s still on diet control to be honest...” (1.6)

“The differences before and after was quite staggering to be honest... ...staggering what could be achieved with just a minimal amount of exercise ...” (1.7)

“...you can physically see yourself getting fitter and readings getting better... ... I’m convinced, would say convinced that it makes a massive difference” (1.8)

Ferrand et al. (2008) report male T2DM participants facilitators for exercise as being knowledge acquisition, skills development for disease control, and awareness of the relationship between exercise behaviour and its health-promoting effects. In light of such findings it is plausible that for participants of Group 1 the sub-theme ‘belief’ reflected how the exercise programme helped facilitate continued physical activity behaviour among the predominantly male interviewees (nine males in a group of eleven) via the same facilitating processes proposed by Ferrand and colleagues.

5.4.1.2 Group 2

The theme of ‘barriers to physical activity’ which emerged among Group 2 interviewees reflected factors restricting physical activity behaviour among these participants. Within this theme emerged the sub-themes of ‘information and reinforcement’, ‘body mass and blood glucose stability’ and ‘other medical conditions’.

The sub-theme, ‘information and reinforcement’, suggested the majority of Group 2 participants perceived a lack of comprehensive support in terms of more extensive information and reinforcement pertinent to physical activity...

“The information I have received has helped but the problem is changing bad habits I have developed over the years” (2.2)

“A lot of the exercise information is rigid and I don’t think it’s very realistic” (2.6)

... akin to what is received within dietary advice.

“On track with the diet, but still room for improvement with exercise” (2.3)

“The diet is well covered, it’s the exercise side of things where I struggle and there isn’t as much help there as there is with say the healthy eating plans” (2.7)

“I feel my diet is quite good, exercise is a different story... ...I don’t know how or where to start sometimes” (2.8)

The importance of more varied physical activity ‘information and reinforcement’ is of particular interest given that Whittemore et al. (2005) suggests predictors of dietary...
self-management were support, confidence in living with diabetes and better psychosocial adjustment. Similar factors to those described by Whittemore and colleagues affecting physical activity behaviour were attributed to the exercise programme by interviewees of Group 1. The importance of providing more comprehensive information and reinforcement is further emphasised by Gatewood et al. (2008) who suggests when there is little individual experience of physical activity patients are more likely to assume physical activity will not affect their health, and Plotnikoff et al. (2010b) who suggests a lack of more comprehensive materials promoting physical activity is widely reported as a barriers to encouraging activity participation among healthcare providers.

The suggestion of a lack of comprehensive information supporting physical activity behaviour is further supported by the emergence of ‘body mass and blood glucose stability’, as a barrier to physical activity for half of all Group 2 interviewees. Some of individuals suggested that concerns over their body mass restricted their physical activity behaviour.

“I used to be able to do more, than I can now... ...I struggle because of my weight...” (2.2)

“Being overweight plays a big factor... ... I didn’t realise how ill I was until being diagnosed with diabetes” (2.7)

While being overweight is one of the most commonly reported barriers to regular physical activity (Van Roijen et al., 2002; Donahue et al., 2006; Mier et al., 2007; Ferrand et al., 2008), concern arising from blood glucose stability...

“I don’t seem to be able to get the weight down or blood glucose levels under control” (2.1)

“I find it difficult to keep blood glucose levels low and stable” (2.4)

“I’m not sure how to manage my blood sugar levels before, during and after I exercise” (2.5)

… may be more closely related to a fear of exercise (Lawton et al., 2006; Mier et al., 2007). Both overweight and blood glucose stability concerns suggests that some patients within Group 2 may be unaware of the potential merits of physical activity and exercise and/or have not received appropriate supporting information on how to overcome these concerns. In either instance, a need for more comprehensive support, information and reinforcement would be advocated.
Like overweight as a barrier to exercise behaviour, physical limitations are also commonly reported among individuals with or at risk of developing T2DM (Van Roijen et al., 2002; Donahue et al., 2006; Mier et al., 2007; Ferrand et al., 2008). Half of the participants of Group 2 also referred to the sub-theme ‘other medical conditions’ reflecting participants’ perception that their physical ailments other than diabetes contributed to their physical inactivity.

“my arthritis has made physical activity very difficult” (2.3)
“I find it difficult to sleep at night and that often makes me too tired to exercise” (2.7)
“I’d prolapsed a disc in my back which for a long period of life curtailed my exercise...” (2.9)
“I had so much swelling and inflammation around the left knee joint, that it was just basically impossible...” (2.10)

While co-morbidities and physical limitations are commonly reported barriers to physical activity among individuals with T2DM, it is the detrimental impact of perceived barriers on physical activity behaviour as highlighted by Aljasem et al. (2001) and Plotnikoff et al. (2006) that is of concern. Both Aljasem and Plotnikoff suggest that among individuals with T2DM, decreasing physical activity and exercise participation is strongly associated with perceived physical disability. This may to some extent help our understanding of the apparent contradiction between ‘barriers to physical activity’ and the emergence of ‘awareness’. ‘Awareness’ encompassed three sub-themes illustrating the majority of participant’s in Group 2 recognised and accepted the ‘seriousness of [their] condition’ a need to ‘control’ their condition, as well as perceived ‘personal responsibility’ in terms managing their condition. In the sub-theme, ‘seriousness of condition’ participants appear to describe how motivation for self-management behaviour arose from an appreciation of the complications that follow should they not take self-care actions.

“I know what can happen if I don’t look after myself” (2.1)
“I know if I don’t my manage the diabetes it will become a problem” (2.2)
“If I don’t stay on top of things, I know the diabetes can become a serious threat” (2.5)
“I try to keep it as under control as possible because I know what can happen if I don’t” (2.7)

Closely aligned to recognition of the seriousness of their condition, the sub-themes of ‘control’...
“I realise the diabetes needs to be controlled I my best to achieve that” (2.2)

“I see my doctor when necessary and make sure I take my medications. I keep a close eye on my diet and make a point of exercising...” (2.5)

“I watch what I eat, always take my tablets after each meal, and walk as often as possible to keep my blood sugar levels as low as possible” (2.6)

“...my diabetes is something that I will always have, by doing the right things I hope I can keep it under control for as long as possible” (2.8)

... and ‘personal responsibility’...

“it’s really up to me to take care of myself” (2.3)

“The buck stops with me so to speak...I’m responsible for my own actions, and so it’s really down to me to look after the diabetes” (2.5)

“My doctor, the diabetes nurse and the dietician can only give me advice and the information...in the end it’s up to me” (2.7)

“I think it’s very much the case that you do take personal responsibility” (2.9)

... suggest that Group 2 participants understood a need to act upon this understanding and knowledge.

An understanding of the implications of diabetes may be an important antecedent for initiation of self-management behaviours aimed at controlling the condition. However, among Group 2 participants translation of understanding into actual initiation and maintenance of self-management behaviours, particularly physical activity, is not apparent, as only two participants reported achieving the physical activity guidelines for 6 months or longer. Participants in Group 2 may not view physical activity as a solution to the seriousness of their condition in relation to other management behaviour such as diet or medication adherence, which may also affect their behaviour choices (Collins et al., 2009) or this sense ‘awareness’ may simply be overwhelmed by perceived barriers to physical activity as supported Aljasem et al. (2001).

The theme ‘why PA’ emerged reflecting Group 2 participants reasons for partaking in physical activity behaviour both before (‘pre-’) and after (‘post-’) diagnosis of their diabetes. Half of Group 2 participants referred to facilitators for physical activity pre-diagnosis as; increased fitness, pleasure and enjoyment.

“...I enjoyed it... ...but no real structured exercise like the gym or anything like that” (2.2)
“... to get a bit more fitter... ...lose a bit of weight” (2.4)

“I enjoyed physical activity and leading an active lifestyle in the past, but I think for about 5 years before I was diagnosed I didn’t really do anything” (2.5)

“... just walking, gardening that sort of thing... ...not a lot to be honest” (2.6)

“It was a pleasure, training was a pleasure... ... it was something I enjoyed doing” (2.9)

Following diagnosis, Group 2 participants continued to provide enjoyment and pleasure of physical activity, alongside weight-loss as well as glycaemic control as reasons for the behaviour.

“...it’s not because I feel, I need [to], it’s because I feel I want to exercise” (2.9)

“...to find out that I’ve got this.. I wouldn’t intend to let it get any worse, that’s the way I feel so I be more determined now to keep active and watch dieting” (2.4)

“I think the exercise worked and I think the exercise helped to keep my weight down a little bit” (2.5)

“I feel that if my sugar levels go down that much...and it’s quite a significant drop after going on the exercise bike, there’s ah it’s gotta be doing some good” (2.9)

“I do enjoy the water aerobics and the exercises” (2.10)

The motives for physical activity emergent from ‘why PA’ - particularly, enjoyment and glycaemic control - are consistent with those described by Group 1 participants and previous research (Van Roijen et al., 2002; Donahue et al., 2006). However, given that fewer participants reported reasons for physical activity following diagnosis of their diabetes suggests the connection between physical activity and successful diabetes self-management has not been fully realised by participants of Group 2. This is further supported by eight out of ten participants of Group 2 reporting they did not reach the recommended physical activity guidelines. Again, this has implications for physical activity orientated treatment in diabetes management, suggestive of a need for more comprehensive physical activity promotion within standard care approaches.

Lastly, there was a tendency among participants of Group 2 to discuss how ‘perceived support’, in terms of both peer support...

“I have a better understanding of my diabetes, and getting together with other people with diabetes has helped me a great deal to accept and cope with the illness” (2.5)

“I live on my own, so chatting with others with diabetes has helped me a lot” (2.6)

…and family members…
My partner eats and does what I do.... in terms of physical activity, we would walk together in the evenings and that (2.2)

My wife has been a considerable support... ... taking on the same lifestyle – walking and exercising, and watching what we eat (2.3)

I get a lot of support from the family and the other people I’ve know who have got it [diabetes] as well (2.7)

... had a valuable role in successful self-management behaviour, an observation supported by Mier et al. (2007) who also suggests family support can facilitate physical activity behaviour among individuals with T2DM.

5.4.2 Mapping emergent themes against the self-determination theory
Where possible the emergent themes and sub-themes from Groups 1 and 2, representing barriers and facilitators to physical activity behaviour, were mapped against constructs of the SDT (Deci and Ryan, 1985; 2000) - autonomy, competence, and relatedness as well as intrinsic, extrinsic and amotivation (described in detail in Chapter 2). This fusion was performed so that unlike previous studies which simply produced a list of barriers and facilitators, the present study would place the results in a theoretical framework in an attempt to identify how these factors may influence the satisfaction of the basic psychological needs and affect self-determined motivation for physical activity behaviour. Whilst it is recognised that there is a potential degree of subjectivity to this process the mapping of themes and sub-themes also served to anchor the observations of the present study with a validated and widely accepted research theory which along with information concerning participants, data collection and data analysis procedures detailed within the methods could support the degree of transferability and dependability of the present study findings beyond the bounds of this project. The researcher sought to ensure objectivity and credibility of the mapping process by adhering to the confines of the SDT and aligning the emergent themes and sub-themes with validated construct definitions (Deci and Ryan, 1985; 2000; Vallerand, 2001) displayed in Tables 5.3 and 5.4.

Following interviews with Group 1 participants, ‘behaviour initiation’ encompassing the sub-themes of ‘response to diagnosis’ and ‘lending a hand’ emerged. In the context of SDT, ‘response to diagnosis’ may reflect initial extrinsic motives to volunteer for the programme in the sense that behaviour was performed as a means to an end - to improve their condition - the benefits of engaging in the activity being
separate from the activity itself, for example for enjoyment or pleasure, as proposed by Vallerand (2001). However, ‘lending a hand’, a disposition to take the good of others as an end in itself (altruism), also appeared to be an important factor in motivating participants to volunteer for the exercise programme. While both ‘response to diagnosis’ can be described in terms of extrinsic motivation, it is plausible that ‘lending a hand’ reflected motivation which was initiated freely and emanated from each individual participant, suggesting a high level of autonomy and intrinsic motivation existed on their behalf prior to commencing the exercise programme. Participant’s motivation for the exercise programme and continued behaviour maintenance (indicated by reports of achieving recommended level of activity for 6 months or more) following programme completion suggests autonomy and intrinsic motives inclusive of enjoyment and pleasure evidenced in ‘learning through doing’ rather than extrinsic factors were central to continued physical activity among individuals with T2DM supported by Ryan et al. (1997). In a study by Thøgersen-Ntoumani and Ntoumanis (2006) healthy individuals who reported exercising regularly for longer than 6 months scored higher on measures of self-determined motivation and lower on controlled motivation compared with individuals who reported exercising less regularly. Further, higher scores for self-determined motivation were also found to predict stronger intentions to engage in exercise behaviour (Thøgersen-Ntoumani and Ntoumanis, 2006). Although there is little research examining physical activity and exercise behaviour among individuals with T2DM from the perspective of SDT, a recent study emanating from the DARE trial (described in Chapter 2) lends support to the findings of the present study and those observed by Thøgersen-Ntoumani and Ntoumanis (2006). The longitudinal study by Fortier et al. (2011) investigated how self-determined motivation changed in T2DM patients (n=175) as they moved through the stages of change over a six-month exercise programme. Hierarchical linear modelling revealed that patients who progressed through the stages of change for exercise behaviour experienced an overall increase in self-determined motivation, while individuals who did not progress through the stages experienced a reduction in self-determined motivation from three to six months. The authors suggested that individuals who engage in regular exercise at six months are more likely to maintain initial increases in self-determined motivation (Fortier et al., 2011).
In contrast to facilitating sub-themes of ‘response to diagnosis’ and ‘lending a hand’ emergent from Group 1, ‘barriers to physical activity’ encompassing three sub-themes; ‘information and reinforcement’, ‘body mass and blood glucose stability’, and ‘other medical conditions’ emerged from interviews among Group 2 participants.

The recurrent sub-theme ‘information and reinforcement’ common to the majority of Group 2 participants represented a perceived lack of comprehensive information, reinforcement and support pertinent to physical activity behaviour. SDT (Deci and Ryan, 1985) provides a possible explanation for this theme as a barrier to physical activity behaviour in that vital to self-determined or intrinsic motivation is sense of choice or freedom to engage in a behaviour - autonomy - a sense of freedom or choice which participants of Group 2 perceived not to be available to them. Williams et al. (1998a, 1998b) have suggested that patients who are exposed to SDT motivational approaches to diabetes treatment are more likely to improve glycaemic control outcomes and adhere to medical regimen if they perceive their healthcare provider offers treatment choices. Significantly, perceived choice has been shown to be an important antecedent of autonomous regulation of behaviour which in turn can lead patients to feel more competent in initiating and maintaining health behaviour change (Williams et al., 2004).
<table>
<thead>
<tr>
<th>Construct</th>
<th>Brief description...</th>
<th>Emergent theme</th>
<th>Emergent sub-theme</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Autonomy</strong></td>
<td>…a perception of freedom to choose your own course of action</td>
<td>Behaviour initiation</td>
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<td></td>
<td></td>
<td>Learning through doing</td>
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<td></td>
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<td>Peer support</td>
<td>Encouragement</td>
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<td></td>
<td></td>
<td>Belief</td>
<td></td>
</tr>
<tr>
<td><strong>Competence</strong></td>
<td>…a sense of fitting in effectively with the environment</td>
<td>Learning through doing</td>
<td></td>
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<tr>
<td></td>
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<td>Peer support</td>
<td>Encouragement</td>
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<td></td>
<td></td>
<td>Belief</td>
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<tr>
<td><strong>Relatedness</strong></td>
<td>…a perception of connectedness with significant others</td>
<td>Peer support</td>
<td>Encouragement</td>
</tr>
<tr>
<td><strong>Intrinsic motivation</strong></td>
<td>…to experience pleasure and satisfaction inherent in the activity</td>
<td>Behaviour initiation</td>
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<td>Learning through doing</td>
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<td></td>
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<td>Belief</td>
<td></td>
</tr>
<tr>
<td><strong>Extrinsic motivation</strong></td>
<td>…to perceive the benefits of engaging in an activity as separate</td>
<td>Behaviour initiation</td>
<td>Response to diagnosis</td>
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<td></td>
<td>from the activity itself</td>
<td></td>
<td>Lending a hand</td>
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<td>Peer support</td>
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<td>Belief</td>
<td>Dependency</td>
</tr>
<tr>
<td><strong>Amotivation</strong></td>
<td>…characteristic of depression and feelings of incompetence akin to learned helplessness</td>
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### Table 5.4 Mapping the findings from Group 2 onto the self-determination theory

<table>
<thead>
<tr>
<th>Construct</th>
<th>Brief description…</th>
<th>Emergent theme</th>
<th>Emergent sub-theme</th>
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<tbody>
<tr>
<td><strong>Mediators</strong></td>
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</tr>
<tr>
<td>Autonomy</td>
<td>…a perception of freedom to choose your own course of action</td>
<td>Awareness</td>
<td>Control</td>
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<tr>
<td></td>
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<td>Personal responsibility</td>
</tr>
<tr>
<td>Competence</td>
<td>…a sense of fitting in effectively with the environment</td>
<td>Awareness</td>
<td>Control</td>
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<td></td>
<td></td>
<td></td>
<td>Why PA</td>
</tr>
<tr>
<td>Relatedness</td>
<td>…a perception of connectedness with significant others</td>
<td>Perceived support</td>
<td></td>
</tr>
<tr>
<td><strong>Levels of motivation</strong></td>
<td></td>
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<tr>
<td>Intrinsic motivation</td>
<td>…to experience pleasure and satisfaction inherent in the activity</td>
<td>Why PA</td>
<td>Pre-diagnosis</td>
</tr>
<tr>
<td>Extrinsic motivation</td>
<td>…to perceive the benefits of engaging in an activity as separate from the activity itself</td>
<td>Awareness</td>
<td>Seriousness of condition</td>
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<td></td>
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<td>Why PA</td>
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<tr>
<td>Amotivation</td>
<td>…characteristic of depression and feelings of incompetence akin to learned helplessness</td>
<td>Barriers to physical activity</td>
<td>Information and reinforcement Body mass and blood glucose stability Other medical conditions</td>
</tr>
</tbody>
</table>
The perceived lack of comprehensive information, reinforcement and support common in Group 2 was further emphasised in the emergence of the sub-themes, ‘body mass and blood glucose stability’, and ‘other medical conditions’. In reference to T2DM patients Peirce (1999) suggests extrinsic motives, such as desire for weight loss, may link overweight and obesity with potentially damaging emotional experiences such as embarrassment, ridicule and fear. Further Peirce (1999) argues that focusing on weight loss through increased physical activity levels may lead to irreconcilable differences in patient’s expectations and subsequent outcomes. While a desire for weight loss may be described in terms of extrinsically motivated behaviour, there is evidence to suggest that internalisation of exercise behaviour regulation may be predictive of weight loss among non-diabetic individuals (Silva et al., 2010).

Although the study did not involve individuals with T2DM, those at risk of the condition, in this instance overweight and obese females participated in a 1-year behaviour change intervention addressing physical activity participation and weight management. The longitudinal intervention investigated the effect of experimentally manipulated perceived need support, motivational regulations, and included a 2-year follow-up period during which no intervention was received on 3-year weight change. The application of SDT to physical activity and weight management demonstrated significant effects on 1- and 2-year autonomous regulations, 2-year physical activity, and 3-year weight change. The study suggested sustained moderate and vigorous exercise mediated long-term weight change however, all forms of motivation were not predictive of long-term behavioural outcomes indicating that a link between experimentally increased autonomous motivation and exercise and long-term weight loss maintenance existed. Whether the goals of a treatment programme be increased physical activity, weight management or improved glycaemic control Silva et al. (2010) highlight both the importance of interventions targeting the internalisation of exercise behavioral regulation, and the importance supporting exercise and physical activity as positive and meaningful experiences rather than simply focusing on immediate behavior change in overweight/obese individuals.

It is plausible that in contrast to T2DM patients who do not focus on weight loss, such as those in Group 1, participants of Group 2, who referred to body mass and weight loss as reasons for performing physical activity, may be more likely to move along the motivation continuum from intrinsic and extrinsic motives toward non-self-determined amotivation should their expectations of physical activity not be realised (Deci and Ryan, 2000). In contrast, Group 1 participants were involved in an exercise programme which did not place
emphasis on weight loss but instead focused on the importance of physical activity for diabetes management as well as its beneficial effects such as improved body shape and physical conditioning, well-being, reduced anxiety and stress and improved sleeping patterns. References to weight loss evident in ‘pre-’ and ‘post-diagnosis’ sub-themes as a reason for physical activity and the overall tendency of Group 2 participants to perceive barriers to the behaviour may indicate most individuals within the group are extrinsically motivated to perform physical activity, the consequence of which may be reflected by the majority of Group 2 participants failing to achieve the recommended guidelines for physical activity.

The theme of ‘awareness’ contained three sub-themes: ‘seriousness of condition’, ‘control’ and ‘personal responsibility’. Although the overarching theme of ‘awareness’ suggested participants understood the nature of their condition and realised the need for self-management the majority of participants in Group 2 reported not achieving the recommended guidelines for physical activity behaviour. This observation can be described in terms of the multidimensional concept of extrinsic motivation consisting of external, introjected, identified, and integrated regulations which lie along a continuum from low to high self-determination reflecting the internalisation process (Deci and Ryan, 1985). It is plausible that participants in Group 2, despite awareness of the need to manage their diabetes, have not sufficiently internalised physical activity behaviour. Instead their motivations for the behaviour lie along the low self-determination positions of the continuum such as introjection and external regulation.

In contrast, participants of Group 1 could be judged to be at higher self-determination positions on the motivation continuum, experiencing integrated regulation and intrinsic motivation. Participant’s ongoing motivation for physical activity following completion of the exercise programme could be attributed to intrinsic motives and the emergence of ‘learning through doing’ may indicate how the exercise programme created an environment which fulfilled individuals autonomy and competence needs. Fulfilling the psychological needs of autonomy and competence facilitated by exercise programme activities such as short, medium and long-term goal-setting and encouraging participants to find alternative exercise opportunities outside the supported/supervised environment, may also explain the emergence of ‘learning through doing’, a theme which suggests the programme helped individuals to gain the necessary skills and confidence to manage their condition, important determinants of continued physical activity behaviour (Ferrand et al., 2008).
In view of the limited research investigating SDT in the context of physical activity behaviour among individuals with T2DM further insight may be gained from research investigating the use of SDT among cardiac rehabilitation populations. Similarly to the participants of Group 1, patients who participate in cardiac rehabilitation experience environmental shifts (for example, from a supported environment to losing contact with intervention facilitators, peers and exercise facilities) when making the transition from supervised, hospital-based programmes to home-based, independent exercise. Considering these circumstances, the extent to which cardiac rehabilitation participants’ motivation for physical activity and exercise is intrinsically motivated may be a key factor differentiating those individuals who maintain a regimen of regular physical activity and those who do not.

Given the beneficial health implications of maintaining participation in physical activity after cardiac rehabilitation (Taylor et al., 2004) or following diagnosis of diabetes (detailed in Chapter 3) and the important role that self-determined motivation may play in predicting exercise behaviour (Wilson et al., 2008), future investigation of self-determination and physical activity following diagnosis of T2DM is warranted.

Among Group 1 participants the emergence of ‘peer support’ and the sub-themes of ‘encouragement’ and ‘dependency’ suggest the influence and support of peers likely contributed to the exercise programme being considered as an activity-friendly environment. Such ‘encouragement’ may be closely linked with the third basic psychological need postulated by SDT, relatedness, which involves feeling connected, or feeling that one belongs in a given social milieu (Deci and Ryan, 1985; Baumeister and Leary, 1995). The exercise programme attended by participants of Group 1 may have also helped to foster autonomy and competence through creation of an opportunity/environment for knowledge acquisition and skill development for disease control (Fisher, 2006). Van Dam et al. (2005) emphasises the necessity for communication between patients in programmes aimed at developing autonomy and competencies that allow coping with life situations.

Patients who have experienced cardiac rehabilitation report higher levels of psychological need satisfaction regarding exercise and greater self-determined motivation (Russell and Bray, 2009). Subsequently, Russell and Bray (2009) have found self-determined motivation also predicts independent, home-based exercise behaviour following discharge from a cardiac rehabilitation programme. The findings of Russell and Bray (2009) suggest nurturing
psychological needs and self-determined motivation during cardiac rehabilitation may be important in helping patients make the transition from interventionist-supervised exercise to self-managed, independent exercise at home. As autonomy support may help facilitate self-determined motivation for behavioural regulation (Ryan et al., 2008) and exercise behaviour among participants involved in cardiac rehabilitation (Russell and Bray, 2010) it may be an important modifiable social–environmental factor that can have an indirect impact on exercise adherence following diagnosis of diabetes. Given the finite duration of short-term exercise interventions and the potential impact of exercise leaders and peer support and encouragement on satisfying autonomy needs and self-determined motivation and outcome behaviour, exercise interventions supported by the SDT framework for individuals among newly diagnosed and individuals with long-term T2DM merits further research.

The ‘peer support’ and ‘learning through doing’ themes which can be described in the context of autonomy support, were notably absent among the interviewees of Group 2. The reported barriers to physical activity including demand for more information and reinforcement, and a focus on body mass among Group 2 participants, could in theory hinder patients progress towards increasing their physical activity levels. Within the context of the SDT, previous research investigating the motivation continuum may help to explain the self-reported action and non-action of Group 1 and 2 participants respectively. Wilson et al. (2003) suggests that among healthy participants recruited to engage in a 12-week structured exercise program, identified regulation predicted exercise behaviours, exercise attitudes and physical fitness. Furthermore, introjected regulation has been shown to be positively correlated with strenuous exercise behaviour (Wilson et al., 2002). Ryan (1995) suggests a behaviour which constitutes an externally motivated activity requires internalisation for initiation and maintenance of the action. A possible explanation for participants in Group 2 failing to achieve recommended guidelines is that although physical activity behaviour was recognised as important, participants were simply positioned at the low self-determination end of the continuum with little or no opportunity to move along the continuum towards more internalised motives for the behaviour. Finally, the theme ‘belief’ emergent among Group 1 participants represented conviction and confidence in the benefits of physical activity that was not evident among Group 2 participants. ‘Belief’ as a facilitator for the initiation and maintenance of physical activity may reflect an interaction between intrinsic and extrinsic motives. For example, extrinsic motives may lead to the behaviour being performed as a means to an end (Vallerand, 2001) in the first instance - ‘response to diagnosis’. However intrinsic motivation
may be exemplified when the benefits of the behaviour began to be realised during the exercise programme. Realisation of benefits combined with the pleasurable experience (closely aligned to peer interaction) and satisfaction stemming from the activity itself (Biddle and Nigg, 2000) - ‘learning through doing’. Internalisation of behaviour regulation and motivation may have been further established through feelings of personal investment, satisfaction, autonomy and competence - all of which may be vital to independent, self-determined motivation for physical activity behaviour maintenance.

5.4.2.1 Summary

Although the cross-sectional and qualitative nature of the present study makes it difficult to draw conclusions about the causality of how motivational mechanisms affect the findings, the themes which emerged from Group 1 – ‘learning through doing’, ‘peer support’ and ‘belief’ – alongside self-reported physical activity behaviour and good glycaemic control, suggest satisfaction of autonomy needs and self-determined motivation may represent important links between long-term physical activity adherence, self-management and diabetes outcomes. These findings build on previous work by Williams et al. (1998a; 1998b) suggesting perceived autonomy support is related to improved long-term glycaemic control and medication adherence. In combination, these studies suggest that interventions, such as the exercise programme described in Chapter 3, which provide choice and a clear rationale for a specified behaviour, support patients’ self-initiation, and help patients build diabetes self-management skills, may support patients’ development of autonomy, competence, and behaviour adherence. Further research investigating the effects of satisfaction of the basic psychological needs and self-determined motivation on physical activity behaviour initiation and maintenance is needed.

Among participants of Group 2, the emergent themes ‘why PA’ and ‘awareness’ suggested participants valued and understood physical activity could provide benefits to the management of their diabetes. However, self-reported physical activity levels suggest despite this knowledge, most participants failed to achieve the recommended guidelines for the behaviour. Mapping of the themes and sub-themes against the SDT suggests an absence of autonomy, competence and relatedness among this small patient group. The emergence of the theme, ‘information and reinforcement’, viewed in combination with participants focus on body mass emergent within the themes of ‘why PA’ and ‘barriers to physical activity’, and suggest Group 2 participants perceived a lack of physical activity specific information and
support and were motivated extrinsically. Further research examining the impact of more comprehensive support, physical activity information and reinforcement is needed to gain further insight into the interplay between these factors and the internalisation of externally motivated behaviour.

5.4.3 Limitations

Findings of this study must be interpreted in the light of several limitations. This study was an exploratory cross-sectional analysis, with a small number of participants utilising semi-structured interview methods and self-report. The cross-sectional nature of data collection precludes a definitive statement on directionality among the hypothesized relations. Future testing of specific behaviours and variables, and longitudinal, randomized controlled interventions to investigate the effectiveness of SDT based physical activity interventions is required. The use of semi-structured interview methods did provide the opportunity to explore in depth and detail complex themes which could not easily be observed. Typically, the small sample size, and personal nature of interviews make the findings of this and other similar studies difficult to generalise. However, anchoring the observations of the present study with tenets of SDT and the provision of detailed information concerning participants, data collection and data analysis procedures may support the degree of transferability and dependability of the present study findings. While it is imperative that further research is performed, the degree of transferability and dependability may be of increased importance given the current paucity of research investigating physical activity behaviour among individuals with T2DM from the perspective of the SDT.

Interview methods are reliant on self-report which are subject to participant biases such as over reporting. Resource limitations meant that the credibility and validity of the interview methods could not be verified by employing additional focus group methods. However, although only semi-structured interview methods were used, supporting data (including age, duration of diabetes, HbA1c, BMI, medication status and current physical activity level assessed via stages of change) were obtained to provide background to and help explain the perceptions and behaviours of the participants under investigation. An important aspect of the present study was the researchers’ background qualifications and experience in relation to the population being investigated and data analysis methods. While familiarity with the population being investigated and immersion in the data collected was important, investigator objectivity and credibility of data analysis was promoted by employing a qualitative
researcher, JS, to independently corroborate the interview transcripts, compare preliminary findings and discuss interpretations before the main themes and sub-themes were derived.

Interviews in particular those of Group 1 participants may have been subject to experimenter and participant biases due to an established rapport originating from the initial exercise programme described in Chapter 3. However, this relationship also helped to create an environment of trust and empathy ensuring openness and honesty during the interview process. It can also be argued a retrospective approach to data collection 4-years after programme completion for participants of Group 1 may have resulted in reduced recall of programme experiences. However, the retrospective approach did allow for exploration of factors influencing long-term exercise maintenance following programme completion. It must also be acknowledged, the participants of the present study were a motivated group of volunteers who chose to participate in the study. The themes which emerged in the present study do not represent an exhaustive list for participants with T2DM. For instance candidate themes including time, dependents, and work commitments were removed following Phase 4 of the thematic analysis. It is possible the relevance of those themes could be augmented in an investigation involving a larger sample size than that of the present study. Similarly, an increased sample size may result in the emergence of additional themes and sub-themes not apparent in the present study. Finally, the use of SDT in this study represents an exploratory approach to understanding themes related to motivation for physical activity behaviour among patients with T2DM. It is possible that the use of other theories and models in isolation or in combination with the SDT may be productive and could be explored in future studies. However, at the present the SDT as a framework for understanding motivation for physical activity behaviour is particularly appropriate for understanding physical activity behaviour among T2DM patients as it proposes internalisation and integration of behaviour and activities is contingent upon internal and external factors which may facilitate or impede the satisfaction of the basic psychological needs and self-determined motivation regulation.

5.4.4 Conclusion

Despite limitations, the findings of the present study suggest a supported exercise programme may help to facilitate behaviour initiation in the first instance and maintenance of behaviour up to 4-years post-programme completion. The facilitating themes afforded by a supported exercise programme appear to include ‘learning through doing’, ‘peer support’ and ‘belief’. In contrast, individuals who receive standard care may be more likely to perceive barriers to
physical activity behaviour. Responses from individuals who experience standard care only suggest a there may be a need for more comprehensive support, information and reinforcement pertinent to physical activity. The present study suggests the SDT provides a useful framework for understanding perceived barriers and facilitators to physical activity affect individual’s motivation for the behaviour. Viewed in alongside previous research investigating patients in a cardiac rehabilitation setting (Russell and Bray, 2009; 2010), evidence suggests interventions which satisfy autonomous needs and promote self-determined behaviour, may facilitate patients’ ongoing physical activity self-management behaviour. The findings also suggest that to overcome barriers and facilitate the initiation and maintenance of regular physical activity greater consideration should be given to the effect of peer support on the internalisation of motivation. The implications for future research are two-fold: 1) development of longitudinal, randomized, controlled interventions aimed at investigating the affect of the basic psychological needs of autonomy, competence and relatedness on initiation and long-term maintenance of physical activity behaviour; and 2) investigate impact of more comprehensive physical activity support, information and reinforcement on the internalisation of externally motivated behaviour.
Chapter 6

General discussion
6.1 Introduction
The overall aim of this thesis was to embrace the empowerment approach attributing the patient an ‘active participant’ role, and seek to further understanding of the factors affecting an individual’s initiation and maintenance of physical activity self-management behaviour from a patient-oriented perspective. In order to accomplish this the present thesis sought to investigate the impact of individualised supported physical activity, explore patients’ perception of physical activity, and explore how factors may affect the use of physical activity self-management behaviour among individuals with type 2 diabetes mellitus (T2DM). Previous research conducted in the area has provided explicit evidence of the powerful effect exercise and physical activity can have on glycaemic control and the incidence of diabetes complications (Boulé et al., 2001; 2003; Sigal et al., 2004; Kelley and Kelley, 2007; Umpierre et al., 2011). However, despite national policy and standards of care (NICE, 2009, 2011; NSF 2010) promoting structured educational programmes such as DESMOND and X-PERT, physical activity continues to be the most difficult self-management behaviour for patients to initiate and maintain (Kavookjian et al., 2007). Low rates of adoption of structured education programmes and the limited support they provide towards increasing physical activity behaviour may further contribute to the high prevalence of physical inactivity observed among this population. As the most underutilised self-management behaviour and current estimates suggesting up to 70% of T2DM patients do not achieve recommended levels for physical activity (Plotnikoff et al., 2011a), effective promotion of this behaviour remains the greatest challenge to researchers and healthcare providers today. Researchers have explored multiple factors relating to low physical activity levels, including: avoidance of physical activity, determinants of physical activity, barriers to physical activity, beliefs about physical activity, and to a lesser degree physical activity triggers (Biddle and Nigg, 2000; Crombie et al., 2004; Lees et al., 2005; Morris and Choi, 2005). Despite a continually growing evidence base confirming the efficacy of physical activity and ongoing efforts to find ways to promote its adoption, there is very little understanding of how individuals with T2DM are motivated to initiate and maintain this key self-management behaviour.

6.2 Summary of key findings
The benefits of physical activity remain unrealised for many T2DM patients. In an effort to address this issue three studies were undertaken. Initially, the effect of a 12-week unsupported exercise programme (akin to standard care) and 12-week supported exercise
programme for patients newly diagnosed with diabetes was investigated (Chapter 3). The study suggested a supported exercise programme helped newly diagnosed T2DM patients to achieve moderate-high intensity physical activity 3-5 days·week$^{-1}$ through peer support and encouragement as well as provision of a safe exercise environment, individualised exercise prescription, heart rate monitoring, and supervision. The study also provided evidence to suggest a supported exercise programme significantly improved glycaemic control, through enhanced β-cell function associated with decreased insulin resistance and improved lipid profile. Investigation of intervention effects at an individual level suggested the impact of both standard care and supported exercise was likely to vary between participants. At 1-year follow-up, while improvement in some variables such as HbA$_1c$ were lost among participants who had received supported exercise, reductions in insulin resistance (HOMA$_{IR}$) and fasting insulin, as well as improved lipid profile were maintained. Significant improvements in body composition and insulin resistance observed among participants of the standard care programme at 1-year suggested participation in the intervention, even as control participants, may have a positive impact on ongoing exercise behaviour and self-management.

The study described in Chapter 3 was undertaken within a randomised controlled setting involving newly diabetes patients. In contrast, the study described in Chapter 4, involved patients with ongoing diabetes living freely outside of a tightly controlled research environment. In Chapter 4 the study investigated physical activity in diabetes management by exploring possible relationships between physical activity behaviour, theoretical constructs, demographics, diabetes care, and other self-management behaviours including medication adherence, diet and blood glucose testing. In this cross-sectional study, participants on average reported achieving the lower limit for physical activity as recommended by the ACSM and ADA joint position stand (Colberg et al., 2010). However, it was also evident that higher levels of physical activity were reportedly achieved by this population. While the associations observed in the study could not assumed to be causal, and outcomes of self-report methods must be considered with caution, significant between-group differences based on a collapsed stage of change model following exploratory analysis suggested exercise self-efficacy, internal LoC and notably, level of physical activity or exercise advice afforded to patients by their healthcare team could be mediating factors in assisting patients to progress across stages of exercise behaviour change towards increased physical activity levels.
In follow-up to the studies described in Chapters 3 and 4, a study exploring the perception and use of physical activity in diabetes self-management among patients who participated in an exercise programme upon initial diagnosis and patients who received standard care was performed (Chapter 5). The participants of both the exercise programme and those who received standard care were interviewed on average four years after initial diagnosis of their diabetes. Unlike the quantitative research methods undertaken in the previous two chapters, the study described in Chapter 5 utilised a qualitative approach which aimed to investigate in depth and detail patient-centred themes not easily observed within the context of the previous two studies. Using the SDT (Deci and Ryan, 1985; 2000) as a framework to describe emergent themes, the study suggested satisfying autonomy needs and internalisation of behaviour motivation were important facilitators to promoting maintenance of regular physical activity among individuals with T2DM. The study also suggested strategies aimed at supporting physical activity behaviour upon initial diagnosis of diabetes, such as that described in detail in Chapter 3, can help patients establish autonomy and competence in relation to physical activity behaviour which may help to improve their long-term adherence and glycaemic control related outcomes.

The importance of support for physical activity behaviour became evident throughout this thesis. Within Chapter 5 it is evidenced in sub-themes such as ‘peer support’ and ‘information and reinforcement’. These themes are closely related to the observation that the level of physical activity or exercise advice reportedly provided by a healthcare team may be positively associated with achieving increased levels of physical activity among those with T2DM – as observed in Chapter 4. A plausible explanation for these observations and the positive outcomes achieved by the participants of the supported exercise group in Chapter 3 may be drawn from the SDT which hypothesises the satisfaction of the basic psychological needs of autonomy, competence and relatedness foster more autonomous or self-determined behaviour regulation. For example, in situations where choice and autonomy are provided, intrinsic motivation is strengthened (Williams et al., 2004). Environments which facilitate the satisfaction of basis psychological needs and promote self-determined motivation may be an important facilitator of active steps towards coping with diabetes and successfully adopting physical activity self-management behaviour. In combination the three studies undertaken in Chapters 3, 4 and 5 suggests that an environment which provides support for physical activity behaviour in a structure which incorporates initial supervision, individualised exercise prescription, peer support and encouragement, and provides more comprehensive
exercise specific information and reinforcement may be key to promoting autonomy and the internalisation of motivation for physical activity behaviour among individuals with T2DM.

6.3 Implications for clinical practice

Whilst the benefits of exercise compared to no exercise in diabetes patients has been recognised (Dunstan et al., 2002; Goldhaber-Fiebert et al., 2003; Alam et al., 2004) and exercise specific guidelines/recommendations have been established (ACSM and ADA position stand, Colberg et al., 2010) and UK policy and standard promote the behaviour there are substantial research gaps for healthcare providers who wish to engage patients in a physical activity regimen. Low levels of participation in physical activity among this population remain and there is a paucity of research investigating the effects of physical activity and exercise among newly diagnosed T2DM patients in particular. Although further research is required, significantly improved glycaemic control, enhanced β-cell function, decreased insulin resistance and improved lipid profile following a 12-week supported exercise programme compared to no significant improvements following what equates to standard care suggests healthcare professionals must consider more comprehensive individualised physical activity support and advice for newly diagnosed T2DM patients in their care. While previous research (Dunstan et al., 2006) has suggested that improvements in glycaemic control achieved following a supervised exercise intervention can not be sustained in an unsupported setting, the improvements in insulin resistance and lipid profile achieved up to 1-year after programme completion described in Chapter 3 and continued good glycaemic control up to 4-years post diagnosis (as described in Chapter 5) suggests merit in such a supported exercise programme.

A more comprehensive approach to encouraging physical activity and exercise in the management in T2DM is further advocated in the findings described in Chapter 4. Although exploratory, the findings suggest increased levels of physical activity and exercise advice provided by a healthcare team, is associated with reportedly increased levels of physical activity and exercise behaviour. A possible explanation for this and the findings in Chapters 3 and 4 may come from the SDT (Deci and Ryan, 1985) which posits that vital to self-determination or intrinsically motivated behaviour is provision of a greater sense of choice or freedom in engaging in behaviour - autonomy. In this instance, it is plausible that increased volume of information regarding physical activity behaviour may encourage patients to perceive the behaviour with greater intrinsic motivation and autonomy. This finding appears
to challenge previous findings whereby increased advice or information does not necessarily equate to increased physical activity behaviour. However, viewed in conjunction with the observations described in Chapters 3 and 5 such as the importance of individualised support, as well as potential mediators such as exercise self-efficacy and internal LoC, the relationship between support, levels of physical activity and exercise advice, and physical activity self-management behaviour is deserving of further confirmatory longitudinal intervention based research. In the short-term healthcare providers could provide more comprehensive physical activity specific information with relative ease.

The importance of individualised support (Chapter 3) and physical activity advice (Chapter 4) is further described in Chapter 5 within the context of the SDT (Deci and Ryan, 1985; 2000). In Chapter 5 the emergent themes and sub-themes described in relation to previous research utilising the SDT (Thøgersen-Ntouman and Ntoumanis, 2006; Russell and Bray, 2009, 2010; Williams et al., 2009; Fortier et al., 2011) suggests an intervention which satisfies patients’ autonomy needs and promotes self-determined motivation can in turn facilitate patients’ continued physical activity behaviour. This is supported by significant changes in perceived relatedness and perceived autonomy observed following the supported exercise programme reported in Chapter 3. The findings described in Chapter 5 also suggest internalisation of behaviour may be vital to promoting initiation and maintenance of regular physical activity in people with T2DM. However, extrinsic motives may be equally influential and both forms of motivation should be subject to further research. Ryan et al. (1997) suggests adherence to an exercise programme is associated with autonomy and intrinsic motives as opposed to extrinsic motives. It is plausible that for some individuals a supported exercise programme can provide the necessary assistance to move along the motivation continuum from initial extrinsic motives for regular physical activity to intrinsic motives. The importance of information provision acknowledged in Chapter 4 may also be explained in Chapter 5. It is possible that like individuals who participate in cardiac rehabilitation (or participants of the supported exercise programme in Chapter 3), individuals in receipt of a greater variety and volume of physical activity advice, have greater perceived choice, and subsequently greater perceived autonomy and intrinsic motivation (Markland, 1999). The alternative are patients who report having received low levels of physical activity advice from their healthcare team (Chapter 4) or describe a lack of more comprehensive support, information and reinforcement pertaining to physical activity (Chapter 5). Such individuals may be more likely to report extrinsic type motives associated
with low levels of adherence to physical activity behaviour – ensuring the problem of physical inactivity among T2DM patient’s remains.

6.4 Conclusion

This thesis provides evidence to suggest individuals with T2DM can achieve high levels of physical activity and improve the management of their condition and related health outcomes. The present research also suggests more comprehensive physical activity support following diagnosis, and ongoing education and reinforcement than what is currently provided within standard care and promoted as national policy is required if the problem of sedentary behaviour is to be alleviated among this population. Despite a continually growing evidence base supporting the benefits of physical activity for individuals with T2DM, and positive actions at a national level promoting patient-centred education programmes in the UK, physical activity remains an underutilised therapy within diabetes care. It would appear the necessity to move away from an acute-care approach to managing this chronic condition towards an empowerment approach, which views the patient as an ‘active participant’, has not being widely recognised or embraced by either healthcare providers and professionals or the patients themselves. A failure to effectively adopt and promote an empowerment approach through both policy and more robust implementation of quality care standards is likely to ensure physical inactivity will continue to represent the most significant challenge facing researchers and healthcare providers today within diabetes care.

In summary, the work presented in this thesis suggests that:

1) A supported exercise programme can help newly diagnosed T2DM patients to achieve moderate-high intensity physical activity 3-5 days·week⁻¹ assisting glycaemic control and diabetes related outcomes over the short- and long-term;

2) Physical activity advice provided to a patient by their healthcare team may be an important mediator in a patients ongoing self-management behaviour;

3) The importance of physical activity support and advice can be described within the context of the SDT in terms of satisfaction of autonomy needs and the internalisation of behaviour motivation.
This thesis also highlights a number of areas that require further investigation utilising an empowerment approach to diabetes care and self-management:

1) Further studies involving larger cohorts of newly diagnosed T2DM patients investigating the effect of supported exercise;

2) Investigation of phenotype, individualised exercise prescription and magnitude of variable response among T2DM patients;

3) Further longitudinal and intervention based research investigating the potential mediating effects of more comprehensive physical activity and exercise information and reinforcement for patients with T2DM;

4) Development of physical activity interventions utilising the SDT aimed at satisfying patient’s basic psychological needs and promoting self-determined motivation and the internalisation of extrinsically motivated behaviours among patients with T2DM.
References
References


Appendices
Appendix 1
Journal of Sports Sciences

The effect of a supported exercise programme in patients with newly diagnosed Type 2 diabetes: A pilot study

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The effect of a supported exercise programme in patients with newly diagnosed Type 2 diabetes: A pilot study

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Abstract
The aim of this study was to examine the effectiveness of either a standard care programme (n = 9) or a 12-week supported exercise programme (n = 10) on glycaemic control, β-cell responsiveness, insulin resistance, and lipid profiles in newly diagnosed Type 2 diabetes patients. The standard care programme consisted of advice to exercise at moderate to high intensity for 30 min five times a week; the supported exercise programme consisted of three 60-min supported plus two unsupervised exercise sessions per week. Between-group analyses demonstrated a difference for changes in low-density lipoprotein cholesterol only (standard care programme 0.01 mmol·L⁻¹, supported exercise programme 0.6 mmol·L⁻¹; P = 0.04). Following the standard care programme, within-group analyses demonstrated a significant reduction in waist circumference, whereas following the supported exercise programme there were reductions in glycylated haemoglobin (0.6 vs. 0.9%, P = 0.007), waist circumference (101.4 vs. 97.6 cm, P = 0.021), body mass index (30.0 vs. 28.7 kg·m⁻², P = 0.006), total cholesterol (5.3 vs. 4.6 mmol·L⁻¹, P = 0.016), low-density lipoprotein cholesterol (3.2 vs. 2.6 mmol·L⁻¹, P = 0.286), fasting β-cell responsiveness (1.15 × 10⁻⁷ vs. 7.8 × 10⁻⁷ pmol·kg⁻¹·min⁻¹, P = 0.009), and insulin resistance (3.0 vs. 2.1; P = 0.099). The supported exercise programme improved glycaemic control through enhanced β-cell function associated with decreased insulin resistance and improved lipid profile. This research highlights the need for research into unsupported and supported exercise programmes to establish more comprehensive lifestyle advice for Type 2 diabetes patients.

Keywords: Physical activity, Type 2 diabetes, glycaemic control

Introduction
It is well established that Type 2 diabetes mellitus constitutes a significant risk for the development of cardiovascular disease (Urwin, Shaw, Zimmet, & Alberti, 2002). Blair et al. (1995) suggest that Type 2 diabetes patients find themselves with a two- to four-fold higher risk of cardiovascular disease compared with individuals without diabetes, which can be explained in part by the simultaneous presence of risk factors such as hyperglycaemia, obesity, insulin resistance, and dyslipidaemia among diabetes patients (UKPDS Group, 1998). An increasing body of evidence supports the use of exercise interventions in the management of Type 2 diabetes to improve glycaemic control, insulin sensitivity, and reduce the risk of complications of diabetes (Alam et al., 2004; Dunstan et al., 2002; Goldhaber-Fiebert, Goldhaber-Fiebert, Tristan, & Nathan, 2003).

A review of public health interventions aimed at increasing physical activity found that although activity levels often do not reach public health recommendations, increases in activity can be found among interventions that have a common set of attributes (Hilldon, Foster, & Thorogood, 2005). These include the provision of individually tailored advice, goal-setting, self-monitoring, ongoing support, and the promotion of moderate-intensity activity. Supplemented programmes administered over several weeks can improve physical ability and diabetes control in the short term (Dunstan et al., 2002; Goldhaber-Fiebert et al., 2003), but little is known about their long-term effectiveness or how they compare to exercise in unsupervised settings. Short, unsupported programmes that encourage people to exercise at home or in a fitness centre may be more feasible and cost-effective than supervised or supported exercise programmes, but...
their effectiveness is unknown. Alam et al. (2004) investigated supervised and unsupervised exercise in patients diagnosed with Type 2 diabetes for a minimum of 8 years, and found unsupervised exercise had no significant effect. Despite limited research investigating the benefits of supervised and unsupervised exercise programmes for patients with newly diagnosed Type 2 diabetes, programmes in an unsupported context continue to be recommended within standard treatment (Sigal, Kenny, Wasserman, Castaneda-Sceppa, & White, 2006).

The primary objective of the present study was to compare the effectiveness of a standard care programme (akin to standard treatment) and a 12-week supported exercise programme on glycemic control,  β-cell responsiveness, insulin resistance, and lipid profiles during the 3-month period following initial diagnosis of Type 2 diabetes.

Methods

Participants
Thirty treatment-naive patients with Type 2 diabetes diagnosed in the preceding 3 months were recruited from a diabetes clinic. Patients were recruited randomly to the study over a 2-year period. Exclusion criteria included current treatment with oral anti-diabetic drugs or insulin, and severe complications of diabetes, such as evidence of hepatic disease. Other exclusion criteria included changes of ischaemia or cardiac disease at rest or during an exercise tolerance test identified by electrocardiogram, problems with mobility, current use of anti-inflammatory drugs, severe asthma, taking corticosteroids, thyroxine or growth hormones. None of the participants had previously participated in an exercise intervention. Nine participants were excluded due to cardiac anomalies observed during the exercise tolerance test (adapted Bruce protocol; Dwyer & Davis, 2004). Twenty-one participants were randomized to one of two conditions: (1) a standard care programme and (2) a supported exercise programme. The experimental protocol received approval from the South East Wales Research Ethics Committee and the University of Wales Institute Cardiff Ethics Committee. All participants received written and verbal information regarding the nature and potential risks of the study and they were required to provide signed informed consent. Approval for participation was also received from each patient’s general practitioner.

Exercise intervention
Patients in the standard care programme were advised to exercise at moderate- to high-intensity for 30 min five times a week for 12 weeks (as per standard care). The 12-week supported exercise programme consisted of three 60-min exercise sessions per week, plus two unsupported exercise sessions per week (five sessions per week in total). All supported exercise sessions were overseen by a qualified exercise physiologist. During the supported exercise sessions, individualized exercise intensities were determined using the heart rate reserve method (Karevzien, Kentalas, & Mustala, 1997). Each supported exercise session commenced and finished with warm-up (10-min) and cool-down (5-min) periods performed at an intensity of 40–50% heart rate reserve. During weeks 1 and 2, the cardiorespiratory phase progressed to 20–40 min periods of interval training (weeks 3–12). Interval training consisted of low-intensity periods of 1–2 min at 40–50% heart rate reserve and high-intensity periods of 1, 2 or 3 min at 80–90% heart rate reserve. All participants in the supported exercise programme group were advised to complete two additional exercise bouts a week, outside the supported environment. Both groups were asked to keep a record of the unsupported exercise sessions in a training diary. No specific exercise intensities were given to the standard care programme group so that this advice remained within standard care. In addition, participants in the standard care programme were telephoned every other week, as advised by the ethics committee, to check on progress.

Carbohydrate challenge tests
For both carbohydrate challenge tests blood was collected from an indwelling polyethylene intravenous cannula situated in an antecubital fossa vein. After inserting the cannula, a three-way tap was connected through which a slow running saline drip flowed to keep the vein patent. A standard meal tolerance test was performed that consisted of a 500-kcal mixed meal (58% carbohydrate, 22% protein, 20% fat), as previously described by Peter et al. (2006). Fasting blood samples were taken at −30 min and at 0 min. Following the 0-min sample, the standardized meal was given to the patient and consumed within 10 min. Blood samples were then taken at frequent intervals over the following 4 h (10, 20, 30, 40, 50, 60, 75, 90, 120, 150, 180, 210, and 240 min). Samples taken during the standard meal tolerance test were assayed for metabolic (glucose, non-esterified fatty acids) and hormonal...
(insulin, C-peptide) parameters. On a separate occasion, patients underwent a frequently sampled intravenous glucose tolerance test. A second cannula was inserted into the antecubital fossa vein in the contralateral arm in order to give the glucose and insulin. Fasting samples were taken at −30, −15, and 0 min. Following the 0-min sample, glucose (300 mg · kg⁻¹ body mass) was given intravenously over a 2-min period. Blood samples were then withdrawn over the next 20 min (at 1, 2, 3, 4, 5, 6, 7, 8, 10, 12, 14, 16, and 20 min). Twenty minutes after the start of the glucose bolus, an intravenous bolus of insulin (0.05 IU · kg⁻¹, Actrapid) was given and further blood samples were taken over the following 3 h (at 22, 23, 24, 25, 27, 30, 40, 50, 60, 70, 80, 90, 100, 120, 150, and 180 min).

**Laboratory and data analysis**

Plasma glucose was measured by a hexokinase assay (Diasys, Germany) using an automated analyser (Sapphire 180, Biosciat, UK). Insulin and C-peptide were measured by highly specific and sensitive immuno-chemilumimetric assays (Invitron, Moneymouth, UK). Glycosylated haemoglobin was measured using an automated analyser (TOSOH HLC-732 GT) designed for the measurement of glycosylated haemoglobin under routine laboratory conditions (Terremi et al., 2003). Non-esterified fatty acids were measured by the Wako enzymatic-colorimetric method (Alpha Labs, Eastleigh, Hants, UK), which relies upon the acylation of co-enzyme A (CoA) by the fatty acids in the presence of added acyl-CoA synthetase (ACS). Lipids were measured using a routine clinical chemistry analyser. All analyses were performed in the Diabetes Research Unit Laboratory and Biochemistry Department, Llandough Hospital, Wales, UK.

**Modelling**

Insulin secretion rates were calculated using the Windows-based Calculating Pancreatic Response application (Hovorka, Koukou, Southleden, Powrie, & Young, 1998), which provides an insulin secretion model during a standard meal tolerance test allowing for calculation of measures of fasting (M₀) and post-prandial (M₈) beta-cell responsiveness. The model uses C-peptide and glucose concentrations to calculate C-peptide secretion rates, and therefore pre-hepatic insulin secretion rates (C-peptide secretion rate — pre-hepatic insulin secretion rate). Insulin resistance was calculated by homeostasis model assessment (HOMA Calculator V2.2.2) using fasting insulin and glucose concentrations (Levy, Matthews, & Hermans, 1998). The acute insulin response to glucose was taken to be the area under the insulin curve for the first 10 min post glucose during the frequently sampled intravenous glucose tolerance test.

**Statistical analysis**

Normality was determined using the Kolmogorov-Smirnov goodness-of-fit test for continuous data; all data did not meet the assumptions for parametric statistics and were expressed as median [range]. Comparison between baseline and post-intervention data, between the two groups, was conducted using the Mann-Whitney U-test. Comparison between baseline and post-intervention data, within each group, was conducted using the Wilcoxon's signed rank test. Statistical significance was set as P < 0.05. Areas under and above the curve were calculated using the trapezoidal method. Statistical analysis was performed using SPSS for Windows version 17.0 (SPSS, Inc., Chicago, IL). Participant adherence to the unsupported sessions in both the standard care programme and supported exercise programme was calculated by dividing the total number of self-reported exercise sessions by the number of recommended unsupported sessions (5 per week in the standard care programme and 2 per week in the supported exercise programme), multiplied by 100. Participant adherence (%) to the supported exercise programme was calculated by dividing the total number of supported sessions attended by the total number of sessions available, multiplied by 100.

**Results**

Nineteen participants (15 males, 4 females; median age = 59.6 years [range: 44.0-69.0]) completed the 3-month intervention after one participant dropped out of the supported exercise programme, and another was discontinued from the standard care programme after requiring medical attention following a hyperglycaemic event not related to exercise. Both participants’ data were removed from the final analysis. Descriptive characteristics for the standard care programme (n = 9) and supported exercise programme (n = 10) participants at baseline and after the 12-week intervention are shown in Table 1. There were no significant differences in baseline characteristics between the two groups. Adherence to the unsupported exercise completed by all the participants (both groups) was monitored using self-report diaries. Adherence to the five unsupported sessions in the standard care programme group was 69%. The adherence to the two sessions, outside the supported setting, in the supported exercise programme group was 78%. The volume, mode, and intensity of the self-reported exercise varied from participant to participant regardless of...
Table I. Descriptive characteristics for SCP and SEP participants at baseline and after the 12-week intervention (median [range]).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
<th>Pre</th>
<th>Post</th>
<th>Pre-Post Prevalue</th>
<th>SCP-SEP Prevalue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body mass (kg)</td>
<td>SCP</td>
<td>102.5 [82.1-123.2]</td>
<td>101.1 [78.0-123.3]</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>91.5 [74.3-113.2]</td>
<td>87.9 [69.9-112.7]</td>
<td>0.007</td>
<td>N.A.</td>
</tr>
<tr>
<td>Body mass index (kg · m⁻²)</td>
<td>SCP</td>
<td>32.3 [26.4-40.9]</td>
<td>32.0 [29.0-41.2]</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>30.0 [26.3-40.1]</td>
<td>28.7 [23.1-39.4]</td>
<td>0.006</td>
<td>N.A.</td>
</tr>
<tr>
<td>Waist circumference (cm)</td>
<td>SCP</td>
<td>111.1 [99.0-131.0]</td>
<td>107.6 [89.0-130.0]</td>
<td>0.05</td>
<td>N.A.</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>101.4 [83.0-121.0]</td>
<td>97.2 [78.0-116.0]</td>
<td>0.021</td>
<td>N.A.</td>
</tr>
<tr>
<td>Fasting glucose (mmol · L⁻¹)</td>
<td>SCP</td>
<td>8.0 [6.4-11.2]</td>
<td>8.5 [5.4-13.2]</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>7.2 [5.7-9.0]</td>
<td>6.6 [5.3-7.5]</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>Fasting insulin (pmol · L⁻¹)</td>
<td>SCP</td>
<td>139.5 [29.0-207.0]</td>
<td>123.9 [3.0-293.0]</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>100.6 [20.0-241.0]</td>
<td>81.2 [50.0-131.0]</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>HbA₁c (%, )</td>
<td>SCP</td>
<td>6.6 [5.6-7.9]</td>
<td>6.7 [5.7-9.7]</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>6.4 [5.7-8.5]</td>
<td>6.6 [5.5-7.1]</td>
<td>0.007</td>
<td>N.A.</td>
</tr>
<tr>
<td>Total cholesterol (mmol · L⁻¹)</td>
<td>SCP</td>
<td>4.8 [4.1-6.4]</td>
<td>4.7 [4.1-5.2]</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>4.9 [3.8-6.8]</td>
<td>4.6 [3.5-6.7]</td>
<td>0.046</td>
<td>N.A.</td>
</tr>
<tr>
<td>HDL cholesterol (mmol · L⁻¹)</td>
<td>SCP</td>
<td>0.9 [0.7-1.2]</td>
<td>0.9 [0.8-1.3]</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>1.0 [0.9-2.3]</td>
<td>1.3 [0.6-2.4]</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>LDL cholesterol (mmol · L⁻¹)</td>
<td>SCP</td>
<td>2.9 [2.3-3.2]</td>
<td>2.9 [2.3-3.4]</td>
<td>N.A.</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>2.2 [2.2-2.8]</td>
<td>2.6 [2.0-2.9]</td>
<td>0.028</td>
<td>N.A.</td>
</tr>
<tr>
<td>Triglycerides (mmol · L⁻¹)</td>
<td>SCP</td>
<td>1.8 [0.9-4.6]</td>
<td>1.8 [0.7-3.9]</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>1.9 [1.3-3.6]</td>
<td>1.6 [0.7-2.9]</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>Fasting NEFA (mmol · L⁻¹)</td>
<td>SCP</td>
<td>0.4 [0.2-0.6]</td>
<td>0.5 [0.3-1.4]</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>0.4 [0.4-0.6]</td>
<td>0.3 [0.3-0.5]</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
</tbody>
</table>

Note: Standard care programme (SCP), n=9; Supported exercise programme (SEP), n=10; *Reference range <6.4%. Body mass index (BMI); high-density lipoprotein (HDL); low-density lipoprotein (LDL); non-esterified fatty acids (NEFA). P-values > 0.05 not significant (N.A.). No differences between groups were found at baseline.

the group to which they were randomized. Volumes of exercise ranging from 10 min to 2 h were reported, with volumes of 20-40 min of exercise being most common. Modes of exercise varied and included swimming, walking, cycling, bowling, and gardening. Intensity of exercise ranged from light to brisk walking to cycling, which left participants out of breath and sweating profusely. Adherence to the three supported 60-min sessions per week over 12 weeks was calculated as 63% at an average intensity of 77.3% heart rate reserve.

Between-group analyses following the standard care programme and supported exercise programme demonstrated a significant difference for changes in low-density lipoprotein cholesterol only. Low-density lipoprotein cholesterol among the supported exercise programme patients decreased significantly compared with the change observed following the standard care programme (standard care programme vs. supported exercise programme) (0.01 [-0.4 to 0.3] vs. -0.6 [-1.7 to 0.4] mmol · L⁻¹; P=0.04). Following the 12-week standard care programme, within-group analyses demonstrated a significant reduction in waist circumference only (Table I), whereas following the 12-week supported exercise programme, there were significant reductions in glycylated haemoglobin, waist circumference, body mass, body mass index, total cholesterol, and low-density lipoprotein cholesterol (Table I).

Metabolic and hormonal profiles during the standard meal tolerance test

Participants’ responses to a standard meal tolerance test at baseline and after the 12-week intervention are shown in Figure 1. Comparison for fasting and post-prandial glucose, insulin, and non-esterified fatty acids measures demonstrated no significant changes following either the standard care programme or supported exercise programme (Table II). No significant changes in β-cell responsiveness or insulin resistance were observed after the standard care programme; however, following the supported exercise programme, fasting β-cell (M₅) responsiveness and insulin resistance decreased significantly (Table II), while post-prandial β-cell (M₅) responsiveness did not.

Measures of first phase β-cell secretion and insulin sensitivity during the frequently sampled intravenous glucose tolerance test

Following the standard care programme, there were no significant changes in disposition index, glucose effectiveness or insulin response to glucose. A significant increase in the acute insulin response to glucose was observed following the supported exercise programme.
Exercise tolerance test

Exercise tolerance test results for the supervised and unsupervised participants at baseline and 3 months are reported in Table III. Following the standard care programme, significant decreases in heart rate at exercise stages 1, 2, 3, and 4 were observed. No significant changes were observed during recovery phases following the standard care programme. Comparison of heart rate measured during the exercise tolerance test before and after the 12-week supported exercise programme demonstrated significant decreases in heart rate at exercise stages 1, 2, and 3, and recovery phases 1 and 2.

Discussion

Newly diagnosed Type 2 diabetes patients often receive only general advice in the first 3 months after initial diagnosis as standard treatment despite limited research investigating its benefits. The primary objective of the present study was to compare the effectiveness of a 12-week unsupervised exercise programme (akin to standard care) and a 12-week supported exercise programme on glycaemic control, β-cell responsiveness, insulin resistance, and lipid profiles in the 3 months following initial diagnosis of Type 2 diabetes.

Between-group analysis of changes observed following the standard care programme and supported

### Table II: Derived parameters from standard meal tolerance test for SCP and SEP participants at baseline and after the 12-week intervention (median [IQR])

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
<th>Pre</th>
<th>Post</th>
<th>Pre-Post P-value</th>
<th>SCP SEP P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose AUGC 0-240 min (mmol - h⁻¹ - L⁻¹)</td>
<td>SCP</td>
<td>4.6 (2.4-12.5)</td>
<td>3.1 (0.4-12.8)</td>
<td>P.N.A</td>
<td>N.A.</td>
</tr>
<tr>
<td>SE P</td>
<td>4.1 (0.4-1.7)</td>
<td>4.3 (0.4-8.4)</td>
<td>P.N.A</td>
<td>N.A.</td>
<td></td>
</tr>
<tr>
<td>Insulin AUGC 0-30 min (pmol - h⁻¹ - L⁻¹)</td>
<td>SCP</td>
<td>356.8 (326-520)</td>
<td>298.9 (74-505)</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>SE P</td>
<td>266.5 (137-735)</td>
<td>261.5 (110-538)</td>
<td>N.A.</td>
<td>N.A.</td>
<td></td>
</tr>
<tr>
<td>Insulin AUGC 0-240 min (pmol - h⁻¹ - L⁻¹)</td>
<td>SCP</td>
<td>1412.2 (195-1913)</td>
<td>1200.3 (290-322)</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>SE P</td>
<td>1017.6 (345-2005)</td>
<td>1027.8 (642-1929)</td>
<td>N.A.</td>
<td>N.A.</td>
<td></td>
</tr>
<tr>
<td>NEFPA AAC 0-240 min (mmol - h⁻¹ - L⁻¹)</td>
<td>SCP</td>
<td>1.04 (0.58-1.87)</td>
<td>1.04 (0.55-1.50)</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>SE P</td>
<td>0.98 (0.65-1.76)</td>
<td>0.97 (0.66-1.64)</td>
<td>N.A.</td>
<td>N.A.</td>
<td></td>
</tr>
<tr>
<td>M recruit × 10⁻⁹ pmol - kg⁻¹ - min⁻¹</td>
<td>SCP</td>
<td>10.9 (7.1-18.4)</td>
<td>10.8 (5.4-16.0)</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>SE P</td>
<td>11.5 (7.1-15.6)</td>
<td>7.0 (2.1-11.1)</td>
<td>N.A.</td>
<td>0.009</td>
<td></td>
</tr>
<tr>
<td>M overnight × 10⁻⁹ pmol - kg⁻¹ - min⁻¹</td>
<td>SCP</td>
<td>11.3 (7.1-48.1)</td>
<td>36.0 (15.6-51.8)</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>SE P</td>
<td>11.5 (7.1-15.6)</td>
<td>39.7 (24.2-77.0)</td>
<td>N.A.</td>
<td>N.A.</td>
<td></td>
</tr>
<tr>
<td>HOMAış</td>
<td>SCP</td>
<td>3.5 (1.7-7.4)</td>
<td>3.1 (1.3-6.1)</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>SE P</td>
<td>5.0 (1.4-4.1)</td>
<td>2.1 (1.2-5.8)</td>
<td>N.A.</td>
<td>0.049</td>
<td></td>
</tr>
<tr>
<td>ΔTbg</td>
<td>SCP</td>
<td>35.3 (16.0-100.6)</td>
<td>31.8 (11.2-50.0)</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>SE P</td>
<td>20.4 (9.8-37.2)</td>
<td>27.2 (12.1-45.0)</td>
<td>N.A.</td>
<td>0.05</td>
<td></td>
</tr>
</tbody>
</table>

Note: Standard care programme (SCP), n = 9. Supported exercise programme (SEP), n = 10. Area under the curve (AUC), area above the curve (AAC), fasting β-cell function (M₀), post-prandial β-cell function (Mᵢ), homeostasis model assessment (HOMA); insulin resistance (α₀); acute insulin response to glucose (ΔTbg). P-value > 0.05 not significant (N.A.). No differences between groups were found at baseline.
Table III. Exercise tolerance test results (heart rate, beats · min⁻¹) for SCP and SEP participants at baseline and after the 12-week intervention (median [range]).

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre</th>
<th>Post</th>
<th>Pre-Post</th>
<th>P-value</th>
<th>SCP-SEP</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercise stage 1</td>
<td>SCP</td>
<td>124.9 [118–139]</td>
<td>121.3 [110–136]</td>
<td>0.05</td>
<td>N.S.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>130.8 [124–139]</td>
<td>127.7 [110–138]</td>
<td>0.03</td>
<td>N.S.</td>
<td></td>
</tr>
<tr>
<td>Exercise stage 2</td>
<td>SCP</td>
<td>154.2 [127–183]</td>
<td>136.0 [117–149]</td>
<td>0.05</td>
<td>N.S.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>138.6 [122–146]</td>
<td>133.7 [115–142]</td>
<td>0.036</td>
<td>N.S.</td>
<td></td>
</tr>
<tr>
<td>Exercise stage 3</td>
<td>SCP</td>
<td>145.0 [136–170]</td>
<td>137.3 [120–163]</td>
<td>0.015</td>
<td>N.S.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>148.6 [139–153]</td>
<td>141.6 [122–159]</td>
<td>0.021</td>
<td>N.S.</td>
<td></td>
</tr>
<tr>
<td>Exercise stage 4</td>
<td>SCP</td>
<td>158.4 [144–181]</td>
<td>150.9 [135–164]</td>
<td>0.011</td>
<td>N.S.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>158.8 [145–169]</td>
<td>155.0 [140–172]</td>
<td>N.S.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recovery phase 1</td>
<td>SCP</td>
<td>149.6 [120–160]</td>
<td>141.4 [120–160]</td>
<td>N.S.</td>
<td>N.S.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>150.9 [126–161]</td>
<td>136.9 [116–164]</td>
<td>0.026</td>
<td>N.S.</td>
<td></td>
</tr>
<tr>
<td>Recovery phase 2</td>
<td>SCP</td>
<td>152.3 [110–150]</td>
<td>126.6 [108–152]</td>
<td>N.S.</td>
<td>N.S.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SEP</td>
<td>136.4 [110–153]</td>
<td>115.3 [82–146]</td>
<td>0.008</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note: Standard care programme (SCP), n=9; Supported exercise programme (SEP), n=10. P-values > 0.05 not significant (N.S.). No differences between groups were found at baseline.*

The exercise programme demonstrated a significant change in low-density lipoprotein cholesterol only. Given the small sample size in the present study, it is likely that particularly large between-group changes (baseline to post-intervention) would be required to demonstrate a statistically significant outcome. Also, the exercise load within each group may not be enough to coax out other metabolic differences between the groups.

Clinically significant changes were observed when comparing the standard care programme with the supported exercise programme for a number of variables. For example, an overall difference of −0.5% for glycosylated haemoglobin (standard care programme vs. supported exercise programme: +0.1 vs. −0.4%) was shown, where glycosylated haemoglobin was reduced in nine of ten of the supported exercise programme participants compared with a reduction in only three of nine participants in the standard care programme group. The supported exercise programme also showed an overall difference of −1.0 mmol·L⁻¹ for fasting plasma glucose (+0.5 vs. −0.6 mmol·L⁻¹), again in favour of the supported exercise programme. Furthermore, the exclusion of 9 of 30 participants from the study due to cardiac anomalies observed during the exercise electrocardiogram contributed to the small sample size, but also emphasized the risk of cardiovascular disease among newly diagnosed Type 2 diabetes patients, stressing the importance of effective early treatment and the risks associated with exercise for this population.

In the present study, within-group analyses demonstrated that glycosylated haemoglobin decreased significantly by 0.4% (6.4 vs. 6.0%) following the supported exercise programme, whereas the standard care programme saw an overall increase of 0.1% (6.6 vs. 6.7%). The clinical significance of this finding can be gauged from the UK Prospective Diabetes Study (UKPDS Group, 1998), where glycosylated haemoglobin decreased by 0.6% among patients randomized to intensive glycaemic control with metformin. Such a reduction was associated with reduced microvascular complications (UKPDS Group, 1998). Significant reductions in body mass (91.7 vs. 87.9 kg) were also observed following the supported exercise programme. Reductions in glycosylated haemoglobin (1.8%) and body mass (1.0 kg) have also been reported by Goldhaber-Fiebert et al. (2003) following a 12-week tri-weekly walking programme (60 min per session). Dunstan et al. (2002) found significant decreases in glycosylated haemoglobin in a resistance training ± weight loss group when compared with a weight loss only group at 3 months (0.6 vs. 0.07%), suggesting exercise is imperative for improved glycosylated haemoglobin concentration. A meta-analysis of exercise interventions (Boulé, Haddad, Kenny, Wells, & Sigal, 2001) concluded improved glycosylated haemoglobin was mediated by exercise and not by changes in body mass. Boulé et al. found that exercise interventions that averaged three sessions per week for 16 weeks at intensities of 30–75% maximum oxygen uptake (VO₂max) reduced glycosylated haemoglobin by approximately 0.66%. This finding compares well with the outcome of the present study, where supported exercise group patients exercised at an average intensity of 77.3% heart rate reserve three times a week for only 12 weeks. Alam et al. (2004) provided similar within-group findings to the present study. Glycosylated haemoglobin (8.7 vs. 7.7%), body mass index (30.7 vs. 28.7 kg·m⁻²), non-esterified fatty acids (0.9 vs.0.5 mmol·L⁻¹), and insulin resistance indicated by HOMAIR (8.2 vs. 5.2) improved among patients (diagnosed for a minimum of 8 years) participating.
in a supervised exercise intervention consisting of 4 sessions per week, at 70% \( VO_{2\text{max}} \) for 6 months. No significant changes were observed within the unsupervised group.

One of the first defects seen in the development of Type 2 diabetes is a decrease or loss in the first phase insulin response to intravenous glucose (Owens, Luzio, & Coates, 1996). In the present study, the overall post-prandial \( \beta \)-cell response did not change following a supported exercise programme, although an improvement in early phase post-prandial insulin response was seen as demonstrated by a significant improvement in the acute insulin response to glucose (20.4 vs. 27.2) in conjunction with significant improvements in glycosylated haemoglobin, which reflects both fasting and post-prandial glucose levels, among the supported exercise programme participants. Significant improvement in the acute insulin response to glucose in conjunction with significant improvements in glycosylated haemoglobin levels may also suggest a slowing of the natural progression of the disease (Weyer, Bogardus, Mott, & Pratley, 1999) among newly diagnosed patients in the supported exercise programme. The improved early phase insulin release may be attributable to the significantly reduced insulin resistance (3.0 vs. 2.1) also observed within the supported exercise group, which in turn could have a sparing effect on the function of the \( \beta \)-cells. Reduced insulin secretion indicated by a significant decrease in fasting \( \beta \)-cell responsiveness (11.5 \( \times 10^{-9} \) vs. 7.0 \( \times 10^{-9} \) pmol \( \cdot \) kg\(^{-1}\) \cdot min\(^{-1}\)) was also observed among patients in the supported exercise programme. Using disposition index as a measure of \( \beta \)-cell function, Sletz et al. (2009) found moderate-intensity exercise training improved disposition index significantly more so than vigorous-intensity exercise in sedentary overweight, moderately dyslipidaemic participants. While moderate-intensity exercise was also found to improve insulin sensitivity, there was no compensatory decrease in the acute insulin response to glucose (Sletz et al., 2009). The acute insulin response to glucose has been found to decrease progressively across levels of glucose tolerance (from normal to impaired to diabetic) (Hong et al., 2007), and ongoing loss of \( \beta \)-cell function may limit the ability of exercise interventions to aid glycaemic control in Type 2 diabetes patients over the long term.

In Type 2 diabetes patients, high levels of visceral adiposity have been found to lead to elevated plasma non-esterified fatty acids, increased fatty acid oxidation, and decreased basal glucose utilization and oxidation (Cusi, Kashyap, Gastaldelli, Bajaj, & Cerasi, 2007). Evidence also supports the association of dyslipidemia and insulin resistance with increased visceral adiposity (Despré et al., 1990). Within-group analyses following the supported exercise programme demonstrated an improved lipid profile, as indicated by significant reductions in total cholesterol (5.3 vs. 4.6 mmol \( \cdot \) L\(^{-1}\)) and low-density lipoprotein cholesterol (3.2 vs. 2.6 mmol \( \cdot \) L\(^{-1}\)). Schenk and Horowitz (2007) have observed that acute exercise increases triglyceride synthesis in skeletal muscle and prevents fatty acid-induced insulin resistance. Exercise may result in improved fat oxidation leading to a reduction in lipotoxicity in skeletal muscle, liver, and/or the pancreas (Sletz et al., 2009) and in conjunction with decreased waist circumference (101.4 vs. 97.2 cm) indicative of reduced visceral adipose tissue, may help explain the improvement in lipid profile and reduction in insulin resistance observed following the supported exercise programme.

Reductions in heart rate during exercise stages and recovery phases observed in the present study may be indicative of improved cardiopulmonary fitness and improved heart rate recovery, an independent predictor of cardiovascular disease and all-cause mortality among diabetic males (Cheng et al., 2003). The significant reductions in heart rate during the exercise stages of the exercise tolerance test observed following both the standard care programme and the supported exercise programme, and the significantly faster rates of heart rate recovery observed among supported exercise programme participants, suggest higher rates of fitness most likely derived from exercise training undertaken during the 12-week intervention. In the present study, the increase in regular physical activity experienced by those on the supported exercise programme may help to explain improved heart rate recovery (Darr, Bassett, Morgan, & Thomas, 1988), as well as the observed improvement in markers of glucose metabolism such as glycosylated haemoglobin (Giacca, Groenewoud, Tsvi, McKeen, & Zinnman, 1998). Furthermore, in the present study an improvement in heart rate recovery and fasting plasma glucose concentration was observed following the supported exercise programme, and it has been previously reported that fasting plasma glucose is strongly and independently associated with abnormal heart rate recovery (Panzer, Lauer, Brice, Blackstone, & Hoopser, 2002).

The present pilot study suggests that a supported exercise programme helps newly diagnosed Type 2 diabetes patients achieve moderate-to-high-intensity physical activity 3-5 times a week through peer support and encouragement as well as provision of a safe exercise environment: individualized exercise prescription, heart rate monitoring, and supervision. The specific mechanisms responsible for the observations in the present study are not obvious and limit the conclusions that can be drawn.
However, the study does provide evidence to suggest increased regular physical activity and subsequent increased exercise capacity afforded by a supported exercise programme significantly improves glycaemic control, through enhanced β-cell function associated with decreased insulin resistance and improved lipid profile. Twelve weeks of standard care did not provide any significant benefits to patients in terms of glycaemic control, β-cell function, insulin resistance or lipid profile. While the benefits of exercise compared with no exercise in diabetes patients has been recognized (Alam et al., 2004; Dunstan et al., 2002; Goldhaber-Fiebert et al., 2003), further research investigating the effects of unsupported and supported exercise programmes is needed to enable health care professionals to give patients newly diagnosed with Type 2 diabetes more comprehensive lifestyle advice.

References


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Appendix 2
LIFESTYLE-INTERVENTION STUDY

PATIENT INFORMATION SHEET

You have been asked to participate in the above research trial. The following will give you detailed information about the trial, trial products involved, risk and benefits of participating in the trial and the consent procedure. If anything is unclear or you need to know more, please ask the doctor or nurse.

Information about the trial and the trial procedures

The purpose of the trial is to compare the benefits of supervised and unsupervised exercise programmes on fitness levels and control of glucose levels.

This study will be performed with 48 patients with type 2 diabetes and impaired glucose tolerance and is planned to start in April 2005 and end by Dec 2005. The maximum duration for each subject will be approximately 4 months from the first to the last visit.

Your role in the trial

The trial consists of 7 visits including this one.

1. **Visit 1**

   If you decide to participate in the trial after giving written informed consent the following safety checks will be performed: physical examination, weight, blood pressure, pulse. In addition a blood sample will be taken and a heart trace (ECG) will be performed. A pregnancy test will be performed on all women of child-bearing potential.

2. **Visit 2**

   If the safety tests performed on Visit 1 are okay, you will be asked to come to the Diabetes Unit about one week later for an incremental exercise test.

   This study period will be to measure your Maximum Oxygen Uptake; this will involve exercising on a bicycle to assess your overall fitness level and will ensure that the exercise you carry out in the study is appropriate for you.

   It will involve pedaling on a bicycle ergometer for 3 minutes. The workload will be increased after 3 minutes and again every 3 min until you are no longer able to maintain the required pedaling frequency. During this period your breathing will be measured and also baseline body composition measurements will be taken to determine body mass, waist-hip ratio, skinfold thickness and limb (upper arm and leg) circumference.
At the end of the study day the blood glucose checked and you will be allowed to return home. You will be asked to return in approximately 7 days for the next study day.

3. **Visit 3**

You will be asked to come to the Diabetes Investigation Unit about one week later having fasted overnight from 8 p.m.

When you arrive at the Unit in the morning a small plastic tube will be inserted into your arm. This tube will be used for taking blood samples throughout the test. You will be required to lie on a bed for the next 4 hours. You will be given breakfast and blood samples will be taken from the tube for the measurement of blood glucose and insulin. Approximately 100 mls blood will be taken during this study period corresponding to approximately a fifth of the blood given at a blood donation.

You will be asked to return the next day for a similar test but without a meal.

4. **Visit 4**

You will be asked to come to the Diabetes Investigation Unit the next day having fasted overnight from 8 p.m.

When you arrive at the Unit in the morning a small plastic tube will be inserted into each arm. One tube will be used for taking blood samples and the other for giving a dose of glucose directly into the vein. You will be required to lie on a bed for the next 3 hours. Over this period you will be given a dose of glucose into the arm followed 20 minutes later by a small dose of insulin. Blood samples will be taken throughout the 3 hour study period. Approximately 200 mls will be taken during each study period corresponding to approximately two fifths of the blood given at a blood donation.

5. **Training Intervention**

Following these visits you will be advised regarding a healthy diet. You will also be seen by a sports scientist and advised regarding exercise. You will then be placed in a group with either supervised or unsupervised exercise over a 3 month period. The choice of which group you will be placed in will be made randomly (by chance).

Whichever group you are placed in an individual training programme will be devised for you based on your peak heart rate determined during the exercise test. In both groups you will be given an exercise programme consisting of five 30-min sessions per week.
For those patients in the unsupervised programme you will be telephoned fortnightly to assess your response and compliance to the prescribed exercise and nutrition programme. You will also be asked to keep an exercise diary recording the type of activity, duration and intensity of the exercise.

For those in the supervised exercise programme there will be three 30-min supervised circuit sessions and two 30-min unsupervised exercise sessions of choice. The circuit will consist of both aerobic and strength endurance exercise. A 5-min warm up and cool down period will be performed prior and after each 30-min session. A qualified exercise physiologist will supervise all the supervised sessions. A training diary will be kept to record your heart rates during the unsupervised sessions.

6. **Visit 5**

This will take place 3 months after the start of the study and will be the same as Visit 2

7. **Visit 6**

This will be the same as Visit 3

8. **Visit 7**

This will be the same as Visit 4

**Information about risks and benefits**

As with many research projects, much of the benefits will be for future patients. There may be no benefits for the subjects participating in this trial except that many of the tests performed are outside normal practice, and the results of these will be transferred to the physician in charge.

If you feel unwell or any unusual discomfort during the trial, it is important to inform your physician as soon as possible.

**Information about consent procedure**

Participation in this trial is voluntary, and refusal to participate will not affect current or future treatment. Subjects participating in this trial are free to withdraw at any time, and the participation may be terminated at any time at the discretion of the investigator.

**Will my taking part be kept confidential?**

Your data will be kept confidential. At the hospital, your consultant and his team will know that you are taking part in this study. If you consent to take part the research team will inspect your medical records for the purposes of analysing the results. Your records may also be looked at by the
hospital and regulatory authorities to check that the study is being carried out correctly. However your name, or any other personal information, will not be disclosed outside the hospital. Your GP will be told of your participation in the study, providing you agree to this. Your study records will be kept on file at the hospital for a period of at least 15 years. At the end of this period all such records will be destroyed.

**What if I suffer any injury?**
If you suffer any injury or harmful effects as a result of participation in the study then you should speak to the doctor in the first instance.

**What if I decide not to take part or to stop during the study?**
You may say “no” now or at any time during the project without having to give reason or suffer any consequences.

If you require any further information please contact

![Contact Information]

Dr Karianne Backx  
Diabetes Research Unit  
Llandough Hospital  
(029) 20716119 / 715299
Appendix 3
LIFESTYLE INTERVENTION STUDY

Subject Number: _______________
Name of Researcher: _______________

Please initial box:

1. I confirm I have read and understand the patient information sheet, for the above study and have had the opportunity to ask questions.

2. I understand that my participation is voluntary and I am free to withdraw at any time, without giving any reason, without my medical care or legal rights being affected.

3. I have to the best of my knowledge informed the investigator of my previous or present illnesses, medications and of any consultation that I have had with my doctor in the last year. I have informed the investigator of any studies that I have participated in within the last year.

4. I consent for my GP to be informed regarding my participation in this study.

Patient name __________________ Signature __________________ Date ____________
(to be completed by the patient)

Name of person taking consent __________________ Signature __________________ Date ____________
(if different from investigator)

Investigator name __________________ Investigator signature __________________ Date ____________

☐ Copies to Patient, Researcher and Hospital Notes.
Appendix 4
EXERCISE DIARY

COMPONENTS OF EXERCISE

<table>
<thead>
<tr>
<th>Components</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode</td>
<td>Type of exercise</td>
<td>Walking, swimming, golf</td>
</tr>
<tr>
<td>Intensity</td>
<td>Amount of energy used</td>
<td>Low-moderate level: 60% of maximum heart rate</td>
</tr>
<tr>
<td>Duration</td>
<td>Length of exercise session</td>
<td>30-60 minutes per day</td>
</tr>
<tr>
<td>Frequency</td>
<td>How often exercise sessions occur</td>
<td>4 sessions per week</td>
</tr>
<tr>
<td>Progression</td>
<td>An increase or change in the mode, intensity, duration and frequency over a certain period</td>
<td>Increase intensity from 60% to 80% of maximum heart rate; duration from 30 to 60 minutes; frequency from 4 to 6 sessions per week</td>
</tr>
</tbody>
</table>

Your exercise programme should be tailored specifically for you as an individual. Your health status, age, medication, time restraints, interests etc. should be taken into account when you design your programme.

In the 3-month supervised programme you will participate in three organised sessions per week. Besides these organised sessions you will need to fit in an additional 2 sessions that you partake in, outside the organised sessions.

These additional sessions could be anything you enjoy doing in terms of physical activity. You could join an aerobic class in your local community centre, start walking in your lunch break, take up golf, do weights at a gym, or start cycling to work!

By taking part in an exercise programme you will find yourself become more active in everyday life, your general physical activity levels will increase as a result of you becoming fitter and stronger!

The aim of the 3-month programme is that you will be an independent exerciser by the end of it; capable of maintaining your exercise plan, and having the knowledge to progress and reach the goals that you have set yourself.
EXERCISE INTENSITY

Your daily physical activity routine should involve moderate-intense exercise for ~30 min. During moderate-intense exercise you should still be able to talk, although you might find it a little harder then normal. You will find that your heart rate becomes faster, and your breathing increases. It is important to exercise the large muscle groups in the body, such as the legs and arms. The first two weeks of the new ‘lifestyle’ you can break up the 30 min into three 10 min sections. This will enable you to build up your stamina.

Exercise intensity can be measured in different ways, it is important that you learn to manage to stay at the right intensity for you! The scales below give some indication of how you will feel at different exercise intensities. During your daily routine, aim for a rating of 5, between somewhat easy and somewhat hard. As you become a regular exerciser, you will find that it becomes easier to judge the intensity you are working at.

During the 3 months that you take part in the supervised exercise programme, you will get to use a heart rate monitor, another way of keeping track of the intensity you are exercising at.

The scales below only show cycling and running, other forms of exercise might be more suitable for you, such as swimming, circuit classes, or aerobics, try out different things and find out which you enjoy!
WARMING-UP, COOLING DOWN & FLEXIBILITY

Warming-up and cooling down are important parts of exercise. The basic principle is to prepare the body for exercise and to gradually slow down after exercise. During a warm-up the body gradually adjusts to a new physiological state, gradually increasing the blood flow to your muscles, increasing your breathing and stretching your muscles.

One of the aims of your increased physical activity programme is to increase or maintain the range of motion in your joints, and to increase your flexibility. The kind of stretching you will be doing is called ‘static’ stretching. It involves slowly placing the muscle in a stretched position to the point of mild discomfort, and holding it for 10-30 seconds. You should integrate stretching into your exercise programme at least 3 days a week.

Some tips for stretching safely are:
  o Exhale during each stretch
  o Relax and breathe normally
  o Do not bounce as you stretch
  o Stretch to a position of mild discomfort, not pain

Stretching exercises (draw own diagram/descriptions):
# DEFINING YOUR HEALTHY LIFESTYLE

**Principles of a healthy lifestyle:**
1. I must exercise
2. I must control food consumption
3. I must learn from mistakes to improve my action plan

## Example Goal-setting Chart:

<table>
<thead>
<tr>
<th>Long-term goals</th>
<th>Short-term goals Level 1</th>
<th>Short-term goals Level 2</th>
<th>Short-term goals Level 3</th>
<th>Short-term goals Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Glucose control</td>
<td>See healthcare team for recommendations</td>
<td>Analyse diet and identify changes that can be implemented</td>
<td>Decrease daily calories from 1,800 to 1,600</td>
<td>Stick to 1,600 calorie diet &amp; exercise 5-7 d/wk</td>
</tr>
<tr>
<td>2. Lose 10 pounds</td>
<td>See healthcare team for recommendations</td>
<td>Increase frequency of walking from 4-5x/wk</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>3. Run 5 km race</td>
<td>See healthcare team for recommendations</td>
<td>Substitute jogging for walking 1x/wk</td>
<td>Walk for 20 min 4-5x/wk</td>
<td>Sign up for 5 km run with local charity, run 30 min 5x/wk</td>
</tr>
</tbody>
</table>

## Your Goal-setting Chart

<table>
<thead>
<tr>
<th>Long-term goals</th>
<th>Short-term goals Level 1</th>
<th>Short-term goals Level 2</th>
<th>Short-term goals Level 3</th>
<th>Short-term goals Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NAME:</td>
<td>WEEK:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>-------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Monday</td>
<td>Friday</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tuesday</td>
<td>Saturday</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wednesday</td>
<td>Sunday</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thursday</td>
<td>Comments:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix 5
INSTRUCTIONS: This set of questions asks for your views about your health. This information will help keep track of how you feel and how well you are able to do your usual activities. Answer every question by marking the answer as indicated. If you are unsure about how to answer a question please give the best answer you can.

1 In general, would you say your health is (Please tick one box):
   - Excellent
   - Very Good
   - Good
   - Fair
   - Poor

2 Compared to one year ago, how would you rate your health in general now? (Please tick one box).
   - Much better than one year ago
   - Somewhat better now than one year ago
   - About the same as one year ago
   - Somewhat worse now than one year ago
   - Much worse now than one year ago

3 During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of your physical health? (Please circle one number on each line).

   Yes  No

Cut down on the amount of time you spent on work or other activities 1 2

Accomplished less than you would like 1 2

Were limited in the kind of work or other activities 1 2

Had difficulty performing the work or other activities (for example, it took extra effort) 1 2
The following questions are about activities you might do during a typical day. Does your health now limit you in these activities? If so, how much? *(Please circle one number on each line).*

<table>
<thead>
<tr>
<th>Activities</th>
<th>Yes, Limited A Lot</th>
<th>Yes, Limited A Little</th>
<th>Not Limited At All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vigorous activities, such as running, lifting heavy objects, participating in strenuous sports</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Lifting or carrying groceries</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Climbing several flights of stairs</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Climbing one flight of stairs</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Bending, kneeling, or stooping</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Walking more than a mile</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Walking several blocks</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Walking one block</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Bathing or dressing yourself</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (e.g. feeling depressed or anxious)? *(Please circle one number on each line).*

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cut down on the amount of time you spent on work or other activities</td>
<td>1</td>
</tr>
</tbody>
</table>
Accomplished less than you would like

Didn’t do work or other activities as **carefully** as usual

6  During the **past 4 weeks**, to what extent has your physical health or emotional problems interfered with your normal social activities with family, friends, neighbours, or groups? (Please tick one box).

- Not at all □
- Slightly □
- Moderately □
- Quite a bit □
- Extremely □

7  How much physical pain have you had during the past 4 weeks? (Please tick one box).

- None □
- Very mild □
- Mild □
- Moderate □
- Severe □
- Very Severe □

8  During the **past 4 weeks**, how much did pain interfere with your normal work (including both work outside the home and housework)? (Please tick one box).

- Not at all □
- A little bit □
- Moderately □
- Quite a bit □
- Extremely □
These questions are about how you feel and how things have been with you during the past 4 weeks. Please give the one answer that is closest to the way you have been feeling for each item. (Please circle one number on each line).

<table>
<thead>
<tr>
<th>All of the Time</th>
<th>Most of the Time</th>
<th>A Good Bit of the Time</th>
<th>Some of the Time</th>
<th>A Little of the Time</th>
<th>None of the Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did you feel full of life?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Have you been a very nervous person?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Have you felt so down in the dumps that nothing could cheer you up?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Have you felt calm and peaceful?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Did you have a lot of energy?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Have you felt downhearted and blue?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Did you feel worn out?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Have you been a happy person?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Did you feel tired?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

During the past 4 weeks, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting with friends, relatives etc.)? (Please tick one box).

- All of the time □
- Most of the time □
- Some of the time □
- A little of the time □
- None of the time □
How TRUE or FALSE is **each** of the following statements for you? *(Please circle one number on each line).*

<table>
<thead>
<tr>
<th>Statement</th>
<th>Definitely True</th>
<th>Mostly True</th>
<th>Don’t Know</th>
<th>Mostly False</th>
<th>Definitely False</th>
</tr>
</thead>
<tbody>
<tr>
<td>I seem to get sick a little easier than other people</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I am as healthy as anybody I know</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I expect my health to get worse</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>My health is excellent</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
The following question relates to the reasons why you would either start to exercise regularly or continue to do so. Different people have different reasons for doing that, and we want to know how true each of the following reasons is for you. All 15 responses are to the one question. Please indicate the extent to which each reason is true for you, using the 7-point scale (Please circle one number on each line):

| The reason I would exercise regularly is:                                                                 |
|                                                                                                         | Not At All True | Somewhat True | Very True |
| 1. Because I feel that I want to take responsibility for my own health.                                | 1 2 3 4 5 6 7 |
| 2. Because I would feel guilty or ashamed of myself if I did not exercise regularly.                   | 1 2 3 4 5 6 7 |
| 3. Because I personally believe it is the best thing for my health.                                    | 1 2 3 4 5 6 7 |
| 4. Because others would be upset with me if I did not.                                                | 1 2 3 4 5 6 7 |
| 5. I really don’t think about it.                                                                     | 1 2 3 4 5 6 7 |
| 6. Because I personally believe it is the best thing for my health.                                    | 1 2 3 4 5 6 7 |
| 7. Because I would feel bad about myself if I did not exercise regularly.                              | 1 2 3 4 5 6 7 |
| 8. Because it is an important choice I really want to make.                                           | 1 2 3 4 5 6 7 |
| 9. Because I feel pressure from others to do so.                                                       | 1 2 3 4 5 6 7 |
| 10. Because it is easier to do what I am told than think about it.                                     | 1 2 3 4 5 6 7 |
| 11. Because it is consistent with my life goals.                                                       | 1 2 3 4 5 6 7 |
| 12. Because I want others to approve of me.                                                           | 1 2 3 4 5 6 7 |
13. Because it is very important for being as healthy as possible.

14. Because I want others to see I can do it.

15. I don't really know why.

These questions are about various aspects of you and your experiences with exercise. (Please circle each answer as appropriate).

13 Have you previously exercised regularly 3 times a week for 12 weeks or longer?

Yes No

14 How successful do you feel that your previous exercise activities have been?

1 Not at all successful 2 Somewhat successful 3 Very successful

15 Do you know of other people who have Type 2 Diabetes for a few months or longer?

Yes No

16 If yes, do you know if they use exercise to assist their condition?

Yes No

17 And how successful have they reported they have been using exercise to control their condition?

1 Not at all successful 2 Somewhat successful 3 Very successful
18. Do you have someone influencing your decision to exercise?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

19. If yes, how strongly would you rate their influence on your decision to exercise?

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not at all influential</td>
<td>Somewhat influential</td>
<td>Very influential</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

20. Do you think exercise can assist with the control of your condition?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>Don’t know</th>
</tr>
</thead>
</table>

21. If yes, how much influence do you think it can have on your condition?

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not at all influential</td>
<td>Somewhat influential</td>
<td>Very influential</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Rate the following words as to how best they sum up the way you feel when you discuss or think about exercise:

<table>
<thead>
<tr>
<th></th>
<th>Do not feel strongly</th>
<th>Feel slightly</th>
<th>Feel moderately</th>
<th>Feel strongly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upbeat</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Worried</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Stressed</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Anxious</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Fatigued</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Keen</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Enthusiastic</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Annoyed</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Relaxed</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Tranquil</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Fearful</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Peaceful</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Energetic</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>
The following statements represent different experiences people have when they exercise. Please answer the following questions by considering how YOU TYPICALLY feel while you are exercising.

1. I feel that I am able to complete exercises that are personally challenging
2. I feel attached to my exercise companions because they accept me for who I am
3. I feel like I share a common bond with people who are important to me when we exercise together
4. I feel confident I can do even the most challenging exercises
5. I feel a sense of camaraderie with my exercise companions because we exercise for the same reasons
6. I feel confident in my ability to perform exercises that personally challenge me
7. I feel close to my exercise companions who appreciate how difficult exercise can be
8. I feel free to exercise in my own way
9. I feel free to make my own exercise program decisions
10. I feel capable of completing exercises that are challenging to me
11. I feel like I am in charge of my exercise program decisions
12. I feel like I am capable of doing even the most challenging exercises
13. I feel like I have a say in choosing the exercises that I do
14. I feel connected to the people who I interact with while we exercise together
15. I feel good about the way I am able to complete challenging exercises
16. I feel like I get along well with other people who I interact with while we exercise together
17. I feel free to choose which exercises I participate in
18. I feel like I am the one who decides what exercises I do
Appendix 6
This questionnaire contains items that are related to your visits with a health-care practitioner (or group of practitioners) in which your exercising was discussed in any way. Health-care practitioners (doctors, nurses, counsellors, etc.) have different styles in dealing with patients, and we would like to know very specifically about your experience of your provider(s) in any encounters when your exercising was discussed. Your responses will be kept confidential. Please be honest and candid. In some cases, you may have met with only your physician; in other cases you may have discussed your diet with several people. If you have met only with your physician, please respond with respect to him or her; if you have met with several practitioners concerning this issue, please answer in terms of your experience of all these practitioners together. Please indicate the extent to which each reason is true for you, using the 7-point scale (Please circle one number on each line):

### The reason I would exercise regularly is:

<table>
<thead>
<tr>
<th></th>
<th>Not At All True</th>
<th>Somewhat True</th>
<th>Very True</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I feel that my health-care practitioners have provided me with choices and options about exercising regularly (including not exercising regularly).</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>I feel my health-care providers understand how I see things with respect to my exercising regularly.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>My health-care providers convey confidence in my ability to make changes regarding my exercising regularly.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>My health-care practitioners listen to how I would like to do things regarding my exercise.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>My health-care practitioners encourage me to ask questions about my exercising.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>My health-care practitioners try to understand how I see my exercising before suggesting any changes.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
</tbody>
</table>
The following statements represent different experiences people have when they exercise. Please answer the following questions by considering how YOU TYPICALLY feel while you are exercising.

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>19. I feel that I am able to complete exercises that are personally challenging</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>20. I feel attached to my exercise companions because they accept me for who I am</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>21. I feel like I share a common bond with people who are important to me when we exercise together</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>22. I feel confident I can do even the most challenging exercises</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>23. I feel a sense of camaraderie with my exercise companions because we exercise for the same reasons</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>24. I feel confident in my ability to perform exercises that personally challenge me</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>25. I feel close to my exercise companions who appreciate how difficult exercise can be</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>26. I feel free to exercise in my own way</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>27. I feel free to make my own exercise program decisions</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>28. I feel capable of completing exercises that are challenging to me</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>29. I feel like I am in charge of my exercise program decisions</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>30. I feel like I am capable of doing even the most challenging exercises</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>31. I feel like I have a say in choosing the exercises that I do</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>32. I feel connected to the people who I interact with while we exercise together</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>33. I feel good about the way I am able to complete challenging exercises</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>34. I feel like I get along well with other people who I interact with while we exercise together</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>35. I feel free to choose which exercises I participate in</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>36. I feel like I am the one who decides what exercises I do</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>
INSTRUCTIONS: This set of questions asks for your views about your health. This information will help keep track of how you feel and how well you are able to do your usual activities. Answer every question by marking the answer as indicated. If you are unsure about how to answer a question please give the best answer you can.

1. In general, would you say your health is (Please tick one box):
   - Excellent [ ]
   - Very Good [ ]
   - Good [ ]
   - Fair [ ]
   - Poor [ ]

2. Compared to one year ago, how would you rate your health in general now? (Please tick one box).
   - Much better than one year ago [ ]
   - Somewhat better now than one year ago [ ]
   - About the same as one year ago [ ]
   - Somewhat worse now than one year ago [ ]
   - Much worse now than one year ago [ ]

3. During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of your physical health? (Please circle one number on each line).

<table>
<thead>
<tr>
<th>Problem</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cut down on the amount of time you spent on work or other activities</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Accomplished less than you would like</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Were limited in the kind of work or other activities</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Had difficulty performing the work or other activities (for example, it took extra effort)</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>
The following questions are about activities you might do during a typical day. Does your health now limit you in these activities? If so, how much? (Please circle one number on each line).

<table>
<thead>
<tr>
<th>Activities</th>
<th>Yes, Limited</th>
<th>Yes, Limited</th>
<th>Not Limited</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vigorous activities</strong>, such as running, lifting heavy objects, participating in strenuous sports</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td><strong>Moderate activities</strong>, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Lifting or carrying groceries</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Climbing several flights of stairs</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Climbing one flight of stairs</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Bending, kneeling, or stooping</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Walking more than a mile</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Walking several blocks</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Walking one block</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Bathing or dressing yourself</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (e.g. feeling depressed or anxious)? (Please circle one number on each line).

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cut down on the amount of time you spent on work or other activities</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Accomplished less than you would like</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Didn’t do work or other activities as carefully as usual</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>
6 During the past 4 weeks, to what extent has your physical health or emotional problems interfered with your normal social activities with family, friends, neighbours, or groups? (Please tick one box).

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at all</td>
<td></td>
</tr>
<tr>
<td>Slightly</td>
<td></td>
</tr>
<tr>
<td>Moderately</td>
<td></td>
</tr>
<tr>
<td>Quite a bit</td>
<td></td>
</tr>
<tr>
<td>Extremely</td>
<td></td>
</tr>
</tbody>
</table>

7 How much physical pain have you had during the past 4 weeks? (Please tick one box).

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Very mild</td>
<td></td>
</tr>
<tr>
<td>Mild</td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td></td>
</tr>
<tr>
<td>Severe</td>
<td></td>
</tr>
<tr>
<td>Very Severe</td>
<td></td>
</tr>
</tbody>
</table>

8 During the past 4 weeks, how much did pain interfere with your normal work (including both work outside the home and housework)? (Please tick one box).

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at all</td>
<td></td>
</tr>
<tr>
<td>A little bit</td>
<td></td>
</tr>
<tr>
<td>Moderately</td>
<td></td>
</tr>
<tr>
<td>Quite a bit</td>
<td></td>
</tr>
<tr>
<td>Extremely</td>
<td></td>
</tr>
</tbody>
</table>
These questions are about how you feel and how things have been with you during the past 4 weeks. Please give the one answer that is closest to the way you have been feeling for each item. (Please circle one number on each line).

<table>
<thead>
<tr>
<th>Question</th>
<th>All of the Time</th>
<th>Most of the Time</th>
<th>A Good Bit of the Time</th>
<th>Some of the Time</th>
<th>A Little of the Time</th>
<th>None of the Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did you feel full of life?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Have you been a very nervous person?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Have you felt so down in the dumps that nothing could cheer you up?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Have you felt calm and peaceful?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Did you have a lot of energy?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Have you felt downhearted and blue?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Did you feel worn out?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Have you been a happy person?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Did you feel tired?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

During the past 4 weeks, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting with friends, relatives etc.)? (Please tick one box).

- All of the time
- Most of the time
- Some of the time
- A little of the time
- None of the time
How TRUE or FALSE is each of the following statements for you? Please circle one number on each line.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Definitely True</th>
<th>Mostly True</th>
<th>Don’t Know</th>
<th>Mostly False</th>
<th>Definitely False</th>
</tr>
</thead>
<tbody>
<tr>
<td>I seem to get sick a little easier than other people</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I am as healthy as anybody I know</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I expect my health to get worse</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>My health is excellent</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
The following question relates to the reasons why you would either start to exercise regularly or continue to do so. Different people have different reasons for doing that, and we want to know how true each of the following reasons is for you. All 15 responses are to the one question. Please indicate the extent to which each reason is true for you, using the 7-point scale (Please circle one number on each line):

<table>
<thead>
<tr>
<th>Reason</th>
<th>Not At</th>
<th>Somewhat True</th>
<th>Very True</th>
</tr>
</thead>
<tbody>
<tr>
<td>Because I feel that I want to take responsibility for my own health.</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<tr>
<td></td>
<td>4</td>
<td>5</td>
<td>6</td>
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<tr>
<td></td>
<td>7</td>
<td></td>
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<tr>
<td>Because I would feel guilty or ashamed of myself if I did not exercise regularly.</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<tr>
<td></td>
<td>4</td>
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<td>6</td>
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<td></td>
<td>7</td>
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<tr>
<td>Because I personally believe it is the best thing for my health.</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<td></td>
<td>4</td>
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<td>6</td>
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<td></td>
<td>7</td>
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<tr>
<td>Because others would be upset with me if I did not.</td>
<td>1</td>
<td>2</td>
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<td></td>
<td>4</td>
<td>5</td>
<td>6</td>
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<td></td>
<td>7</td>
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<tr>
<td>I really don't think about it.</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<td>4</td>
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<td>6</td>
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<tr>
<td>Because I personally believe it is the best thing for my health.</td>
<td>1</td>
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<td></td>
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<td>6</td>
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<td></td>
<td>7</td>
<td></td>
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</tr>
<tr>
<td>Because I would feel bad about myself if I did not exercise regularly.</td>
<td>1</td>
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<td></td>
<td>4</td>
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<td></td>
<td>7</td>
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<tr>
<td>Because it is an important choice I really want to make.</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<td>4</td>
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<td>6</td>
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<td></td>
<td>7</td>
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<tr>
<td>Because I feel pressure from others to do so.</td>
<td>1</td>
<td>2</td>
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<td>4</td>
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<td>6</td>
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<td></td>
<td>7</td>
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<tr>
<td>Because it is easier to do what I am told than think about it.</td>
<td>1</td>
<td>2</td>
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<td></td>
<td>4</td>
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<tr>
<td>Because it is consistent with my life goals.</td>
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<td>2</td>
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<td>4</td>
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<td>6</td>
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<td></td>
<td>7</td>
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<tr>
<td>Because I want others to approve of me.</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<td></td>
<td>4</td>
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<td>6</td>
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<td></td>
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<tr>
<td>Because it is very important for being as healthy as possible.</td>
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<td>2</td>
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<td></td>
<td>4</td>
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<td>6</td>
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<td></td>
<td>7</td>
<td></td>
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<tr>
<td>Because I want others to see I can do it.</td>
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<td>2</td>
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<td>4</td>
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<td>6</td>
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<td></td>
<td>7</td>
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<td></td>
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<tr>
<td>I don't really know why.</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<td>4</td>
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</tbody>
</table>

These questions are about various aspects of you and your experiences with exercise. (Please circle each answer as appropriate).
13 Have you previously exercised regularly 3 times a week for 12 weeks or longer?

Yes  No

14 How successful do you feel that your previous exercise activities have been?

1  2  3  4  5  6  7
Not at all successful  Somewhat successful  Very successful

15 Do you know of other people who have Type 2 Diabetes for a few months or longer?

Yes  No

16 If yes, do you know if they use exercise to assist their condition?

Yes  No

17 And how successful have they reported they have been using exercise to control their condition?

1  2  3  4  5  6  7
Not at all successful  Somewhat successful  Very successful

18 Do you have someone influencing your decision to exercise?

Yes  No

19 If yes, how strongly would you rate their influence on your decision to exercise?

1  2  3  4  5  6  7
Not at all influential  Somewhat influential  Very influential
20. Do you think exercise can assist with the control of your condition? 

Yes  No  Don’t know

21. **If yes**, how much influence do you think it can have on your condition?

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<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
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<tbody>
<tr>
<td>Not at all influential</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Somewhat influential</td>
<td></td>
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<tr>
<td>Very influential</td>
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</tbody>
</table>

22. Rate the following words as to how best they sum up the way you feel when you discuss or think about exercise:

<table>
<thead>
<tr>
<th>Word</th>
<th>Do not feel very strongly</th>
<th>Feel slightly</th>
<th>Feel moderately</th>
<th>Feel strongly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upbeat</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Worried</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Stressed</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Anxious</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Fatigued</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Keen</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Enthusiastic</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Annoyed</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Relaxed</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Tranquil</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Fearful</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Peaceful</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Energetic</td>
<td>1</td>
<td>2</td>
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<td>4</td>
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</tbody>
</table>
Appendix 7
We would like to invite you to participate in the above study. Before you decide you need to understand why the research is being done and what it would involve for you. Please take time to read the following information carefully.

If anything is unclear or you need more information, please ask us.

**What is the purpose of the study?**

The purpose of the study is to collect information from patients relating to their views on diabetes. A questionnaire will be used to assess; patient self-management, patient confidence in their ability to perform tasks related to the treatment of their diabetes, patient belief that their diabetes is controllable or uncontrollable, and patient perception of the importance of exercise in the treatment of their diabetes.

Information gained from the study will be used in two ways. Firstly, contributing to a PhD thesis, and secondly written as a full report for publication purposes.

**Why have I been invited?**

As a patient with diabetes your views are very important in helping us find out more about the disease and how it affects you personally.

**Do I have to take part?**

Participation in this study is voluntary. If you choose not to take part it will not affect the care you receive for your diabetes in any way. You are free to withdraw at any time. If you do not wish to
take part in the questionnaire, you do not need to give us a reason. If you choose to take part, you will be asked to sign a consent form to show that you agreed to take part.

**What will happen to me if I take part?**

Your role will be to complete a questionnaire, whilst attending your regular diabetes clinic appointment. After completing the questionnaire, you will be given the opportunity to discuss any aspect of the questionnaire in greater detail with the researcher should you wish to do so. Completion of the study should take approximately 30 minutes.

It is hoped that around 300 patients will complete the study. As with many research projects there may be no immediate benefits for participants. However, it is anticipated the study will help to inform future practice, and for those who participate the study provides the opportunity for you the patient to express your views, thoughts and opinions outside of the usual practice.

**What if I decide not to take part or to stop during the study?**

You may say “no” now or at any time during the study without having to give reason or suffer any consequences.

If you require any further information please contact

<table>
<thead>
<tr>
<th>Adrian McCann</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-TRIC Building</td>
</tr>
<tr>
<td>Altnagelvin Area Hospital</td>
</tr>
<tr>
<td>Western Health and Social Care Trust</td>
</tr>
<tr>
<td>Londonderry</td>
</tr>
<tr>
<td>BT47 6SB</td>
</tr>
<tr>
<td>Tel: 028 71 345171 Ext 216609</td>
</tr>
<tr>
<td>E-mail: <a href="mailto:adrian.mccann@westerntrust.hscni.net">adrian.mccann@westerntrust.hscni.net</a></td>
</tr>
</tbody>
</table>
Appendix 8
Type 2 Diabetes Mellitus Patient Questionnaire

Patient Consent

Version 5
01.10.2008

Title of Project:

Name of Researcher:

Please initial box:

5. I confirm I have read and understand the information sheet (Version 5, 01.10.2008) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

6. I understand that my participation is voluntary and I am free to withdraw at any time, without giving any reason, without my medical care or legal rights being affected.

3. I agree to take part in the above study.

_____________________
Patient name

_____________________
Signature

____________
Date

_____________________
Name of person taking consent

_____________________
Signature

____________
Date
Appendix 9
Type 2 Diabetes Mellitus Patient Questionnaire

Please complete the following questionnaire answering all the questions that are applicable to you. Participation in this questionnaire is voluntary and you are free to withdraw at any time. There are no right or wrong answers to the questions in this questionnaire.

Demographics

Q1. What is your age? _____ years

Q2. Sex: □ Male   □ Female

Q3. Please tell us how long you have been diagnosed with having diabetes? _____ years _____ months

Q4. Height __. ___ m / ___ feet ___ inches

Q5. Weight ____ kg / ___ stones ___lbs

Q6. Which of the following best describes your ethnic origin? (please tick √ the answer that applies)
   □ Asian or Asian British (Bangladeshi/Indian/Pakistani/other)
   □ Black or Black British (African/Caribbean/other)
   □ Mixed (White&Asian/White&Black African/White&Black Caribbean/other)
   □ White (British/Irish/other)
   □ Other Ethnic group (specify): ____________________

Q7. Are you currently? (please tick √ the answer that applies)
   □ Employed          □ A homemaker
   □ Self-employed     □ Retired
   □ Out of work less than a year □ Unable to work
   □ Out of work more than a year

Q8a. Please tell us your highest qualification: __________________________

Q8b. Please tell us your profession: __________________________

Q9. Are you currently being treated for any other complications? (please tick √ all the answers that apply)
   □ High blood pressure □ Artherosclerosis
   □ High cholesterol  □ Bleeding in the retina
   □ Chest pain        □ Sore joints
   □ Heart attack      □ Foot sores
   □ Stroke            □ Other (specify): __________________________
Q10. In the past 3 months have you experienced a change in blood sugar that required medical attention? (please tick ✓ all the answers that apply)

□ Low blood sugar (Hypoglycaemic event)  □ High blood sugar (Hyperglycaemic event)

Q11a. Do you know what an HbA\textsubscript{1c} measurement is? □ Yes □ No

Q11b. Most recent HbA\textsubscript{1c} measurement: ________ %  Date: ___/___/___

The following questions ask you about your diabetes self-care activities during the past seven days. If you were sick during the past seven days, please think back to the last 7 days that you were not sick.

**Blood sugar testing**

Following each question, please write the appropriate number of days in the space provided.

Q12. On how many of the last SEVEN DAYS did you test your blood sugar? _____

Q13. On how many of the last SEVEN DAYS did you test your blood sugar the number of times recommended by your healthcare provider? _____

Q14. Which of the following has your healthcare team (doctor, nurse, dietician, or diabetes educator) advised you to do? (please tick ✓ all the answers that apply)

□ Test your blood sugar using a drop of blood from your finger and a colour chart.
□ Test your blood sugar using a machine to read the results.
□ Test your urine for sugar.
□ I have not been given any advice either about testing my blood or urine sugar level my diet by my healthcare team.
□ Other (specify): ____________________________

**Foot care**

Q15. Do you have any diabetes related foot problems?

□ Yes (please answer the following questions)
□ No (please go to Q21.)

Following each question, please write the appropriate number of days in the space provided.

Q16. On how many of the last SEVEN DAYS did you check your feet? _____

Q17. On how many of the last SEVEN DAYS did you inspect the inside of your shoes? _____

Q18. On how many of the last SEVEN DAYS did you wash your feet? _____

Q19. On how many of the last SEVEN DAYS did you soak your feet? _____
Q20. On how many of the last SEVEN DAYS did you dry between your toes after washing? ______

Medications

Following each question, please write the appropriate number of days in the space provided.

Q21. On how many of the last SEVEN DAYS, did you take your recommended diabetes medication OR insulin injections? ______

Q22. On how many of the last SEVEN DAYS did you take your recommended number of diabetes pills? ______

Q23. Which of the following medications for your diabetes has your doctor prescribed? (please tick √ the answer that applies)

☐ An insulin shot 1 or 2 times a day.
☐ An insulin shot 3 or more times a day.
☐ Diabetes pills to control my blood sugar level.
☐ I have not been prescribed either insulin or pills for my diabetes.
☐ Other (specify):______________________________

Smoking

Q24. Have you ever smoked?

☐ Yes (please answer Q25.)
☐ No (please go to Q26.)

Q25. When did you last smoke a cigarette? (please tick √ the answer that applies)

☐ More than 2 years ago. ☐ 1 to 3 months ago.
☐ 1 to 2 years ago. ☐ Within the last month
☐ 4 to 12 months ago. ☐ Today.

Diet

Following each question, please write the appropriate number of days in the space provided.

Q26. On how many of the last SEVEN DAYS do you think you have followed a healthy eating plan? ______

Q27. On how many of the last SEVEN DAYS did you eat five or more servings of fruits and vegetables? ______

Q28. On how many of the last SEVEN DAYS did you eat high fat foods such as red meat or full-fat dairy products? ______

Q29. On how many of the last SEVEN DAYS did you space carbohydrates evenly through the day? ______
Q30. On average, over the past month, how many DAYS PER WEEK have you followed your eating plan? ______

Q31. Which of the following has your healthcare team (doctor, nurse, dietician, or diabetes educator) advised you to do? (please tick √ all the answers that apply)
□ Follow a low fat diet
□ Follow a carbohydrate diet
□ Reduce the number of calories you eat
□ Eat lots of food high in dietary fibre
□ Eat lots (at least 5 servings per day) of fruit and vegetables
□ Eat very few sweets (for example: desserts, non-diet soft drinks, chocolate)
□ I have not been given any advice about my diet by my healthcare team.
□ Other (specify): ______________________________

For each of the following statements, please circle the appropriate number indicating how you feel.
The following statements assess your confidence in your ability to follow diabetic routines

Q32. I can fit my diabetes self-treatment routine into my usual lifestyle

Q33. I think I’ll be able to follow my diabetes plan even when I am away from home

Q34. I can carry out practically all of the self-care activities in my daily routine

Q35. I am confident in my ability to manage my diabetes

The following statements assess your confidence in your ability to self treat

Q36. I can recognise when my blood sugar is too high

Q37. When I feel sick, I can test my blood more than I routinely do

Q38. I can do what is recommended to prevent low blood sugar reactions

Q39. I can figure out what self-treatment to administer when my blood sugar is low

Q40. I can figure out when to call my doctor about problems with
my feet

For each of the following statements, please circle the appropriate number indicating how you feel.

The following statements assess your confidence in your ability to manage diabetes

<table>
<thead>
<tr>
<th>Q41. I feel unsure about having to use what I know is required for good self-treatment every day</th>
<th>Strongly disagree</th>
<th>Strongly agree</th>
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<tr>
<td>1 2 3 4 5 6</td>
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<table>
<thead>
<tr>
<th>Q42. I don’t think I can follow my diabetes routine every single day</th>
<th>Strongly disagree</th>
<th>Strongly agree</th>
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<tr>
<td>1 2 3 4 5 6</td>
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<table>
<thead>
<tr>
<th>Q43. I’m not sure I’ll be able to follow my diabetic diet every day</th>
<th>Strongly disagree</th>
<th>Strongly agree</th>
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<tr>
<td>1 2 3 4 5 6</td>
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<table>
<thead>
<tr>
<th>Q44. I’m not sure I’ll be able to follow my diabetic diet when the people around me don’t know I have diabetes</th>
<th>Strongly disagree</th>
<th>Strongly agree</th>
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<td>1 2 3 4 5 6</td>
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The following statements assess your confidence in your ability to manage diet

<table>
<thead>
<tr>
<th>Q45. I can stay on my diabetic diet when I eat in familiar places away from home</th>
<th>Strongly disagree</th>
<th>Strongly agree</th>
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<tbody>
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<td>1 2 3 4 5 6</td>
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<table>
<thead>
<tr>
<th>Q46. I can stay on my diabetic diet when I eat in unfamiliar places</th>
<th>Strongly disagree</th>
<th>Strongly agree</th>
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<td>1 2 3 4 5 6</td>
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<table>
<thead>
<tr>
<th>Q47. When I go to parties, I can follow my diet plan</th>
<th>Strongly disagree</th>
<th>Strongly agree</th>
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<tbody>
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<td>1 2 3 4 5 6</td>
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</table>

The following statements assess your confidence in your ability to exercise

<table>
<thead>
<tr>
<th>Q48. I can’t exercise unless I feel like exercising</th>
<th>Strongly disagree</th>
<th>Strongly agree</th>
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<tbody>
<tr>
<td>1 2 3 4 5 6</td>
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<table>
<thead>
<tr>
<th>Q49. I can exercise several times a week</th>
<th>Strongly disagree</th>
<th>Strongly agree</th>
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<td>1 2 3 4 5 6</td>
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<table>
<thead>
<tr>
<th>Q50. I feel confident I can exercise 15 to 30 minutes, 4 to 5 times per week</th>
<th>Strongly disagree</th>
<th>Strongly agree</th>
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<td>1 2 3 4 5 6</td>
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<tr>
<th>Q51. I feel confident I can do gentle exercises for muscle strength and flexibility three to four times per week (range of motion, using weights, etc.)</th>
<th>Strongly disagree</th>
<th>Strongly agree</th>
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<td>1 2 3 4 5 6</td>
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<table>
<thead>
<tr>
<th>Q52. I feel confident I can do aerobic exercise such as walking, swimming, or bicycling three to four times each week</th>
<th>Strongly disagree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Q53. I feel confident I can exercise without making symptoms worse</th>
<th>Strongly disagree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
For each of the following statements, please circle the appropriate number indicating how you feel.

The following statements assess whether you feel aspects of your diabetes are under your control

**Q54.** If I take care of myself, I can minimise diabetic complications

Strongly disagree 1 2 3 4 Strongly agree 5 6

**Q55.** The main thing which effects whether I will develop diabetic complications is what I do for myself

1 2 3 4 5 6

**Q56.** If I avoid diabetic complications it is because of my efforts

1 2 3 4 5 6

**Q57.** If my diabetes goes out of control, it s my own behaviour which determines how soon I get back in control again

1 2 3 4 5 6

**Q58.** If I take the right actions, I can keep my diabetes in control

1 2 3 4 5 6

**Q59.** The main thing which affects my diabetes is what I do for myself

1 2 3 4 5 6

The following statements assess whether you feel aspects of your diabetes are under the control of powerful others

**Q60.** Having regular contact with other people who have diabetes is the best way for me to avoid developing diabetic complications

1 2 3 4 5 6

**Q61.** My family has a lot to do with whether or not I develop diabetic complications

1 2 3 4 5 6

**Q62.** If I’m able to avoid diabetic complications its because other people (for example, doctors, nurses, family, friends) have been taking good care of me

1 2 3 4 5 6

**Q63.** When I’m able to keep my diabetes in control, its usually because other people (for example, doctors, nurses, family, friends) have been taking good care of me

1 2 3 4 5 6

**Q64.** My family has a lot to do with my diabetes being in control or out of control

1 2 3 4 5 6

**Q65.** Having regular contact with my doctor is the best way for me to keep my diabetes in control

1 2 3 4 5 6
For each of the following statements, please circle the appropriate number indicating how you feel.

The following statements assess whether you feel aspects of your diabetes are due to chance

Q66. Avoiding diabetic complications is largely a matter of good fortune

<table>
<thead>
<tr>
<th>Strongly disagree</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
</table>

Q67. No matter what I do, I’ll probably develop diabetic complications

<table>
<thead>
<tr>
<th>Strongly disagree</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
</table>

Q68. If it’s meant to be my diabetes will stay in control

<table>
<thead>
<tr>
<th>Strongly disagree</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
</table>

Q69. When my diabetes goes out of control, it’s usually by accident

<table>
<thead>
<tr>
<th>Strongly disagree</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
</table>

Q70. No matter what I do my diabetes is likely to go out of control

<table>
<thead>
<tr>
<th>Strongly disagree</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
</table>

Q71. Most things that affect my diabetes happen by accident

<table>
<thead>
<tr>
<th>Strongly disagree</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
</table>

Exercise
Following each question, please write the appropriate number of days in the space provided.

Q72. On how many of the last SEVEN DAYS did you participate in at least 30 minutes of physical activity? _____

Q73. On how many of the last SEVEN DAYS did you participate in a specific exercise session (such as swimming, walking, biking) other than what you do around the house or as part of your work? _____

Q74. Which of the following has your healthcare team (doctor, nurse, dietician, or diabetes educator) advised you to do? (please tick √ all the answers that apply)

- □ Get low level exercise (such as walking) on a daily basis.
- □ Exercise continuously for at least 20 minutes at least 3 times per week.
- □ Fit exercise into your daily routine (for example, take stairs instead of elevators, park a block away and walk etc.)
- □ Engage in a specific amount, type, duration and level of exercise.
- □ I have not been given any advice about exercise by my healthcare team.
- □ Other (specify): ______________________________
Q75. The following question assesses past exercise activity levels

Indicate your level of participation in sport or exercise for the different periods of your life (please tick √ the answer that applies for each period of your life)

<table>
<thead>
<tr>
<th>Age</th>
<th>Never</th>
<th>Seldom</th>
<th>Sometimes</th>
<th>Often</th>
<th>Very often</th>
</tr>
</thead>
<tbody>
<tr>
<td>16-25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>26-35</td>
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<td>36-45</td>
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<td>46-55</td>
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<td>56-65</td>
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<td></td>
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<tr>
<td>66-75</td>
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<td></td>
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<tr>
<td>75+</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Q76. Do you think exercise can assist with the control of your diabetes? (please tick √ the answer that applies)

- □ Yes
- □ No
- □ Don’t know / unsure

The recommended guidelines are 30 minutes of moderate intensity physical activity 5 days per week, or 3-5 days per week of vigorous intensity activity for 20 minutes.

Q77. Which one of the following statements best describes you? (please tick √ the answer that applies)

- □ I do not achieve the recommended guidelines, and have little interest in doing so
- □ I am currently thinking about trying to achieve the recommended guidelines
- □ I do some physical activity, but not as much as the recommended guidelines
- □ I have been achieving the recommended guidelines during the past 6 months
- □ I have been achieving the recommended guidelines for longer than the past 6 months

Q78. Are you currently a member of a sports club / fitness centre / do you exercise independently? (please tick √ all the answers that apply)

- □ Independently
- □ Sports club member
- □ Swimming pool member
- □ Fitness centre member
- □ Walking / rambling club member
- □ Other (specify): _____________________
Q79. If **No** to the previous question, do any of the following reasons apply? (please tick ✓ all the answers that apply)

☐ I do not see the point in exercising
☐ I am afraid / anxious to exercise
☐ I do not have time
☐ I have other health problems making exercise difficult
☐ I do not know where I can exercise

(specify):________________________

☐ I do not like exercising
☐ Exercise tires me out
☐ Exercising is too expensive
☐ I weigh too much to exercise
☐ Other

Thank you for the taking part in the questionnaire.

If you would like the opportunity to discuss any of the questions or issues investigated in this questionnaire in greater detail please inform the researcher who is present when you have completed the questionnaire.

Thank you for your time and patience.
We would like to invite you to participate in the above study. Before you decide you need to understand why the research is being done and what it would involve for you. Please take time to read the following information carefully.

Part 1 tells you the purpose of this study and what will happen to you if you take part. Part 2 gives more detailed information about the conduct of the study.

If anything is unclear or you need more information, please do not hesitate to contact us.

**What is the purpose of the study?**

The purpose of the study is to collect information relating to physical activity and the self-management of Type 2 diabetes. A semi-structured interview will be performed in which a number of open ended questions will be asked. These questions will focus on your diabetes, your self-management practices, and your confidence and beliefs about physical activity and the role it may or may not play in the self-management of your diabetes.

Information gained from the study will be used in two ways. Firstly, contributing to a PhD thesis, and secondly written as a full report for publication purposes.

**Why have I been invited?**

As a patient with diabetes your views are very important in helping us find out more about the disease and how it affects you personally.
Do I have to take part?

Participation in this study is voluntary. If you choose not to take part it will not affect the care you receive for your diabetes in any way. Furthermore, you do not need to give us a reason. Should you agree to take part, you will be asked to sign a consent form to show that you agreed to participation in the study. You will be free to withdraw at any time.

What will happen to me if I take part?

Your role will be to take part in a semi-structured interview. The interview will be recorded and should take approximately 25-30 minutes. You will not be asked to disclose your identity whilst the interview is being conducted and all information that is exchanged between you and the interviewer will be strictly confidential.

As with many research projects there may be no immediate benefits for participants. However, it is anticipated the study will help to inform future practice, and for those who participate the study provides a unique opportunity for you the patient to express your views, thoughts and opinions outside of the usual practice.

If you require any further information please contact

Adrian McCann  
C-TRIC  
Altnagelvin Area Hospital  
Western Health and Social Care Trust  
Londonderry  
BT47 6SB  
Tel: 028 71 345171 Ext 216609  
E-mail: adrian.mccann@westerntrust.hscni.net
Appendix 11
**Type 2 Diabetes Mellitus Semi-structured Interview**

**Patient Consent**

**Version 1**
15.07.2009

Title of Project:
Name of Researcher:

Please initial box:

7. I confirm I have read and understand the information sheet (Version 1, 15.07.2009) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

8. I understand that my participation is voluntary and I am free to withdraw at any time, without giving any reason, without my medical care or legal rights being affected.

3. I agree to take part in the above study.

_________________  ___________________  ____________
Patient name         Signature            Date

_________________  ___________________  ____________
Name of person taking consent Signature    Date
Group 1:  
Follow-up to type 2 diabetes mellitus exercise study,  
Semi-structured interview  

Interview schedule

The semi-structured interview focused on physical activity behaviour in the self-management of diabetes 2 years after participation in a 12-week exercise programme.

The aim of the semi-structured interview was to investigate:
- participants experience of a supervised (S) or unsupervised (U) physical activity programme
- how participants feel physical activity affects their diabetes
- how participants feel physical activity could be promoted

The interview schedule was retained by the interviewer, and the following questions were subject to prompts:
(* denoted a prompt following either a YES / NO participant response)

1. Just let me ask first of all about your diabetes:
   Prompts:
   How long have you had diabetes?
   What treatment do you currently receive for your diabetes (diet controlled/oral meds./insulin)?
   What do you normally do to manage your diabetes?

2. I will now ask you a few questions about physical activity in the past and your experience on the S/U physical activity programme
   a To begin, can you recall your physical activity history prior to commencing the S/U physical activity programme?
      Prompts:
      How would you describe your activity levels?
      Can you recall any +ve/-ve experiences concerning physical activity?
      How would you describe your attitude towards physical activity in the past?
   b Can you recall your reasons for volunteering for the S/U physical activity programme?
      Prompts:
      Concerns about recently diagnosed diabetes, +ve health outcomes, social, environmental, family pressure?
   c How would you describe your experience on the physical activity programme?
      Prompts:
      +ve, empowering, rewarding, assuring
      -ve, over-reliance/ dependant, gruelling, demanding
   d Did the physical activity programme have any effect on how you manage your diabetes?
Prompts:
YES: In what way? (Confidence and Responsibility in managing …) Why do you think this happened?
NO: Can you explain why you feel that way?

3. I will now read out the physical activity recommendation used in developing the programme you participated in.

The recommended guidelines are 30 min of moderate intensity physical activity 5 days·wk$^{-1}$, or 3-5 days·wk$^{-1}$ vigorous intensity activity for 20 min

a Which of the following statements best describes your current level of physical activity:

- I do not achieve the recommended guidelines, and have little interest in doing so
- I am currently thinking about trying to achieve the recommended guidelines
- I do some physical activity, but not as much as the recommended guidelines
- I have been achieving the recommended guidelines during the past 6 months
- I have been achieving the recommended guidelines for longer than the past 6 months

b Can you explain your current level of physical activity?
Prompts:
What are you currently doing – regular/intermittently?
What are your reasons for this? (reliance on meds.,+ve/-ve health, lack of social/enviro., cost)
What has happened since completion of the physical programme? (relapsed, ill-health, or progressed and improved, social – gym, partner/group)

c Has living with diabetes had any effect on your physical activity behaviour?
Prompts:
Motivated, discouraged, impact of duration – movement from newly diagnosed / disease progression

4. Now I would like to discuss how confident you feel about your diabetes management.

a First of all, do you feel confident in your ability to manage your diabetes?
Prompts:
For instance, your ability to measure blood glucose, adjust medication, manage diet, and physical activity levels.
Are there certain behaviours you feel more/less confident about? Why?

b With respect to physical activity in the management of your diabetes, do you feel confident about physical activity?
Prompts:
Are you confident it can help?
Confidence in ability to do physical activity? Do it well? Do it regularly?
Are there certain activities you feel more confident about/prefer? Why? (type, support - independent/group)
How about activities you may still be afraid/too worried to try? Why? (barriers?)
Further Facilitators / Barriers

c Do you feel confident that you can maintain or further develop your current physical activity levels?
  *Prompts:*
  YES: Frequency, intensity, time, type
  NO: Why?

5. I would now like to talk about who is responsible for the management of your diabetes

   a Who takes the lead in the management of your diabetes?
     *Prompts:*
     Individual (you)
     Healthcare team
     Family, friends

   b Is there any part of your diabetes routine you feel is managed well? Or less well?
     *Prompts:*
     Blood glucose testing, medication adherence, diet, physical activity
     Why?

   c Tell me about physical activity and the management of your diabetes

   i Do you take personal responsibility for doing physical activity?
     *Prompts:*
     YES: What has helped you to achieve this? (facilitators, motivation, buddy, environment)
     NO: What deters you? (barriers – physical, environmental)
     Is there anything you can do to overcome these?

   ii Does your family or friends help you to do physical activity?
     *Prompts:*
     YES: What do they do and how? (encourage, support)
     NO: Is it more difficult when they are around?
     Is there anything your family or friends could do to help?

   iii Does your healthcare team help you to do physical activity?
     *Prompts:*
     Do they encourage you?
     Has physically activity been prescribed to you?
     What advice have you been given?
     Is there anything your healthcare team could do to help? (part of routine care, financial/care incentive)

6. Is there anything else you’d like to say that we haven’t talked about?

Thank you.
Appendix 13
Group 2:  
Follow-up to type 2 diabetes mellitus questionnaire study,  
Semi-structured interview

Interview schedule

The semi-structured interview focused on physical activity behaviour in the self-management of diabetes.

The aim of the semi-structured interview was to investigate:
- participants’ experience of physical activity
- how participants feel levels of physical activity levels could be increased
- how participants feel physical activity could be promoted

The interview schedule was retained by the interviewer, and the following questions were subject to prompts:
(* denoted a prompt following either a YES / NO participant response)

3. Just let me ask first of all about your diabetes:
   
   **Prompts:**
   - How long have you had diabetes?
   - What treatment do you currently receive for your diabetes (diet controlled/oral meds./insulin)?
   - What do you normally do to manage your diabetes?
   - How long have you established this routine?

4. I will now ask you a few questions about physical activity.

   **a** To begin, can you recall your physical activity history prior to developing diabetes?
   
   **Prompts:**
   - How would you describe your activity levels?
   - Can you recall any +ve/-ve experiences concerning physical activity?
   - Barriers / Facilitators
   - How would you describe your attitude towards physical activity in the past?

   **b** Do you do physical activity now? Why?
   
   **Prompts:**
   - YES: What are your reasons for doing so? (+ve health, social, environmental)
   - NO: Are there any particular reasons for this? (reliance on meds., -ve health, lack of social/enviro., cost)
   - Has this always been the case? (-ve past experience)
   - If not, what did you do before? Why? What happened between then and now?

   [If not mentioned in answer to above question]

   **c** Has developing and living with diabetes had any effect on your physical activity behaviour?
   
   **Prompts:**
   - Motivated, discouraged, impact of duration – newly diagnosed / disease progression, medication use)
5. Now I would like to discuss how confident you feel about your diabetes management.

   **a First of all, do you feel confident in your ability to manage your diabetes?**
   *Prompts:*
   - For instance, your ability to measure blood glucose, adjust medication, manage diet, and physical activity levels.
   - Are there certain behaviours you feel more/less confident about? Why?

   **b With respect to physical activity in the management of your diabetes, do you feel confident about physical activity?**
   *Prompts:*
   - Are you confident it can help?
   - Confidence in ability to do physical activity? Do it well? Do it regularly?
   - Are there certain activities you feel more confident about/prefer? Why? (type, support - independent/group)
   - How about activities you may still be afraid/too worried to try? Why? (barriers?)
   - Further Facilitators / Barriers

   **c Do you feel confident that you can maintain or further develop your current physical activity levels?**
   *Prompts:*
   - YES: Frequency, intensity, time, type
   - NO: Why?

7. I would now like to talk about who is responsible for the management of your diabetes

   **a Who takes the lead in the management of your diabetes?**
   *Prompts:*
   - Individual (you)
   - Healthcare team
   - Family, friends

   **b Is there any part of your diabetes routine you feel is managed well? Or less well?**
   *Prompts:*
   - Blood glucose testing, medication adherence, diet, physical activity
   - Why?

   **c Tell me about physical activity and the management of your diabetes**

   **i Do you take personal responsibility for doing physical activity?**
   *Prompts:*
   - YES: What has helped you to achieve this? (facilitators, motivation, buddy, environment)
   - NO: What deters you? (barriers – physical, environmental)
   - Is there anything you can do to overcome these?

   **ii Does your family or friends help you to do physical activity?**
   *Prompts:*
   - YES: What do they do and how? (encourage, support)
   - NO: Is it more difficult when they are around?
   - Is there anything your family or friends could do to help?
iii Does your healthcare team help you to do physical activity?

*Prompts:*
Do they encourage you?
Has physically activity been prescribed to you?
What advice have you been given?
Is there anything your healthcare team could do to help? (part of routine care, financial/care incentive)

8. Is there anything else you’d like to say that we haven’t talked about?

Thank you.