Cardiff School of Sport

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CARDIFF METROPOLITAN UNIVERSITY
Prifysgol Fetropolitan Caerdydd

CARDIFF SCHOOL OF SPORT

DEGREE OF BACHELOR OF SCIENCE (HONOURS)

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THE EFFECTS OF VARIED COLD WATER IMMERSION PROTOCOLS ON RECOVERY AND REPEATED PERFORMANCE MEASURES IN MALE RUGBY PLAYERS

(Dissertation submitted under the SCRAM area)

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ABSTRACT

The purpose of this investigation was to observe the effect two different length cold water immersion protocols had upon performance variables and recovery from exercise induced muscle damage. The study aimed to add information to help identify an optimal immersion protocol to facilitate the recovery process.

Quantitative methods were utilised to attain data relative to the aim of the study. 11 university level rugby players were subjected to performance tests at baseline. Performance variables consisted of countermovement jump height and isometric strength measures of knee extensor, knee flexor and hip extensor muscle groups. Participants completed a high volume squat protocol producing muscular damage symptoms. Subjects were randomly assigned into one of three recovery groups. Group one received a single 15 minute cold water immersion, group two received five cyclical two minute immersions and the third group acted as a control group. Participants were re-tested at 24 and 48 hours post exercise.

Statistical analysis of the data displayed that both cold water immersion protocols had no significant effect ($P > 0.05$) on any of the performance variables when compared to the control group. Concluding that cold water immersion protocols used in this study were ineffective at aiding recovery from exercise induced fatigue and restoring pre-exercise performance levels.

Future research should focus on identifying an optimal cold water immersion protocol based on data collected from physiological, psychological and performance variables. This would comprehensively assess and justify the use of cold water immersion as an effective post-exercise recovery modality.

CHAPTER ONE

INTRODUCTION

Training is completed by individuals in order to try and achieve a positive adaptation to their body, skill acquisition or psychological being. Bishop, Jones and Woods (2008) define training as an acute challenge to the body intended to optimise chronic improvements in physiological capabilities. Recovery must take place in order for the physiological effects from the acute challenges to be transferred into chronic improvements. Tomlin and Wenger (2001) define recovery as the return of the body to its pre-exercise state following exercise. Within the game of rugby union there is a high volume of physiological stressors put upon players both in training and competitive fixtures. Recovery from these stressors are important to the players in order to minimise any impairments to performance in a limited recovery time. In an effort to try and maximise recovery within a limited time, modalities have been developed for players and staff to utilise.

A study by Van Wyk and Lambert (2008) discusses the wide range of recovery modalities used in elite modern day sport. Their study stated that the most popular method used was ice baths or cold water immersion (CWI). CWI is a form of cryotherapy which involves the application of cold and/or ice to treat a specific injury. This can be applied in many different forms such as ice packs and ice massage. These methods cause a reduction in temperature to the area applied and have been found to decrease the body’s natural inflammatory response (Swenson, Sward and Karlsson, 1996). Reducing the chemotactic response and decreasing pain perception (Hatzel and Kaminski, 2000) may be the physiological effects which facilitate recovery in rugby union players as contact and collisions can cause micro trauma to the soft tissue of uninjured players.

Although evidence for the effectiveness of CWI remains anecdotal, studies have concluded to have a positive effect on recovery and successive performance (Bailey et al., 2007; Banfi, Melegati and Valentini, 2007; Roswell et al., 2009), however, these studies all have varied water temperature, immersion time, time between immersions and number of immersions. These factors collectively make a protocol which dictate how CWI is performed. There is little evidence supporting an optimal CWI protocol (Bleakley and Davidson, 2009) and it is because of this that teams utilise different protocols depending on player and/or coach preference.

Research into an optimal CWI protocol would aid medical practitioners in their prescription of this recovery modality to players and decrease inhibitory symptoms associated with high volume exercise and fatigue. Athletes improve their overall skills and abilities with consistent performances when training and competing, by optimising the recovery process post-training, it may have a facilitative effect to subsequent performances (Gill, Beaven and Cook, 2006). This research aims to narrow the spectrum and identify an optimal length duration of water immersion for rugby union players after a high volume resistance session.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This literature review will aim to provide a critical analysis of relevant research of topics surrounding delayed onset muscle soreness, possible mechanisms of the cause and various recovery methods and strategies with focus upon water immersion techniques. Previous studies using alternative cold water immersion techniques will also be reviewed in order to develop an effective protocol in relevance to this research.

2.2 Fatigue

When an exercise or activity is performed to a level higher than the individuals' physical capabilities then fatigue will be induced. Fatigue is defined by Knicker et al. (2011) as exercise-induced impairment of performance during sport events. The research further adds that fatigue can be a deterioration of physical, technical, decision-making and psychological skills. Fatigue can be additionally categorized into two separate forms according to Froyd, Millet and Noakes (2013) known as peripheral fatigue and central fatigue. The peripheral form is caused by a direct build-up of end products of metabolic processes along with a reduction in the efficiency of neuromuscular transmission. Central fatigue is the reduction of the initiation of electrical activity from motor neurons which direct and control contracting muscle from the central nervous system (CNS). These types of fatigue may be required In order to increase an individual's physical capabilities. This is achieved through a gradual increase in physical stress applied to their body. This is achieved by increasing training frequency, duration, speed, resistive load or volume and is called the principle of overload (Hass, Feigenbaum and Franklin, 2001). The overload principle according to Stone, Plisk and Collins (2002) is when an individual is provided with a specific stimulus aimed at inducing a desired physical, physiological or performance adaptation. From these increases in training factors such as volume or intensity, damage is caused to the skeletal musculature of the participant's body.

2.3 Delayed Onset Muscle Soreness

Damage caused to the muscle tissue can be felt as general muscle stiffness or can be a more intense pain which could restrict the range of movement (ROM) available at a joint and is known as delayed onset muscle soreness (DOMS) (Cheung Hume and Maxwell, 2003). DOMS is the body's natural inflammatory response to micro-tears within muscular fibres as a result of concentric and eccentric activity from exercises. This is not however limited to gym or sport based activities as working environments such as an office can cause DOMS symptoms due to un-ergonomic equipment (Jay et al., 2014). The way in which DOMS affects an individual is specific to the person according to Kanda et al. (2013). The research states that a person's inflammatory response can differ depending on their sex, age, training mode as well as training duration and intensity. It is generally accepted that DOMS can be perceived by an individual within 12 hours of exercise peaking between 24-48 hours post exercise (Plowmans and Smith, 2008; Eston et al. 1996; Connolly, Sayers and McHugh, 2003). Symptoms are thought to subside within 96 hours, but full recovery of the tissue structures can take up to five-seven days according to Cleak and Eston (1992). It was prematurely believed that lactate accumulation was a mechanism in the symptoms of DOMS however, reliable evidence has been presented by Szymanski (2001) and Cleak and Eston (1992) that although this theory was accepted by many, it can be concluded that there is no positive relationship between lactate accumulation and muscular soreness symptoms. As DOMS symptoms are not experienced until 24 hours post-exercise it can be reliably concluded that lactate accumulation, which peaks immediately post-exercise, cannot be accredited as a primary contributor to the symptoms of DOMS. Research conducted by McHugh et al. (1999) concluded that symptoms experienced by an individual with DOMS is likely to be from a combination of neural, connective tissue and cellular factors. At a cellular level, the etiology of muscular damage can be described as a series of sequential events as displayed in research by Connolly, Sayers and McHugh (2003). The series begins with mechanical damage from exercise causing inflammation, a build-up of edema and free radical proliferation. Damage can occur in the sarcolemma, the sarcoplasmic reticulum, plasma membrane and cytoskeletal areas of the muscular structure. These are affected by Z and A band disruption, degeneration of the filament system and disorganisation of the myofibrils within the myocyte (Friden and Lieber 1992). All factors have an additive effect to the symptoms to which a person suffers, these factors depending on their severity can limit the level of intensity to which an athlete can train or their competitive performance. Cheung, Hume and Maxwell (2003) categorized the effects on performance into perception of functional impairment, joint kinematics, strength and power, altered recruitment patterns and an increased risk of injury. The athletes' perception of their temporary impairment can affect their belief in their own abilities leading them to assume that muscular soreness is a limitation.

2.4 Alternative Muscle Soreness Theories

There has been other theories proposed to explain the mechanisms associated with DOMS, including the muscle spasm, connective tissue damage, muscle damage, inflammation, and enzyme efflux theories. Although these theories have been suggested, the information is still hypothetical, further research would need to be performed in order to validate the actual biological process which occurs after muscle damaging movements (Cheung, Hume and Maxwell, 2003).

2.5 Eccentric Exercise

Dynamic muscular movements can be explained as the stretch shortening cycle (SSC) which is broken down into a concentric and eccentric portion. This is due to the observation that during movements such as walking or hopping, muscular structures are regularly exposed to impact or stretch forces such as gravity (Komi, 2008). The concentric phase involves the shortening action of a muscle while the eccentric phase lengthens the muscle. It is during this eccentric phase that tension is developed whilst the muscle is in a lengthened state which can cause more damage to the muscles involved than the concentric phase (Brown et al. 1997). Rugby strength and conditioning coaches may place larger focus on the eccentric phase during pre-season. Larger amounts of musculature damage, in combination with suitable nutrition can increase muscle mass which is a desired characteristic in rugby players (Duthie, 2006). Eccentric exercises are regularly used in research involving DOMS as the lengthened state of the muscle under the tension of external forces allows for a larger amount of structural damage which can increase the severity of the DOMS. Hamill et al. (1991) utilised a downhill running protocol to induce DOMS as the longer downhill stride demanded a larger eccentric component inducing larger amounts of damage, this elevated creatine kinase activity post-exercise. Creatine kinase is a product of the metabolism and is regularly used as physiological indicator of muscle damage. For future research it was suggested that an exercise model which puts greater stress upon the participants to be performed in order to produce a larger degree of muscle soreness. Byrne and Eston (2002) and Vaile et al. (2008) both utilised bilateral lower body resisted methods with particular focus on the eccentric portion of their respected movements. Byrne and Eston (2002) had their participants perform a high volume squat protocol while Vaile et al. (2008) composed a lower volume leg press protocol with a higher load, 120% of participants' one repetition max score. Both protocols resulted in immediate and prolonged disruption of muscular performance. These methods developed greater levels of perceived muscular soreness and larger levels of mechanical damage in comparison to Hamill et al. (1991) method of downhill running. Outcomes of the referenced exercise protocols were considered when constructing a fatigue protocol in the present study.

2.6 Recovery

As modern day sport becomes more competitive and globalised as a product, athletes have more time invested into them by coaches in order for them to reach a higher level of performance. To achieve optimum levels of physical condition the training process must be scrutinised and precisely planned through periodization cycles which coincide with the player's lifestyle and training age. Kuipers (1998) believes that an athlete must be able to balance their competitive performance with their training load allowing an appropriate amount of recovery time in order to achieve optimal performance. Training volume must therefore be organised around the player's ability to fully recover from the overtraining which is necessary to adapt and progress in certain physical or temporal skills. Bishop, Jones and Woods (2008) define recovery from a practical outlook as a person(s) ability to meet or exceed performance in their given activity. The study further adds elite athletes spend more time in recovery than training, placing more importance on the recovery process at higher levels of performance. Bishop, Jones and Woods (2008) state that an improved recovery protocol could result in a performance plateau of a higher level. The process of recovery can take up to five days or even longer according to Cheung, Hume and Maxwell (2003). The inflammation phase can last 72 hours post-acute injury and it is within this time that DOMS symptoms peak. Recovery should therefore take place immediately post-exercise and if possible, continued throughout the 24 hour window in order to allow maximum effects from the chosen recovery modality (Barnett, 2006).

2.7 Recovery Modalities

There are many available recovery strategies which are used throughout sport, but it usually depends on what works for the specific individual as their perception of the recovery modality can change the outcome. Barnett (2006) lists a number of recovery modalities which are used in modern day sporting environments, massage is a popular choice as it is believed that the soft tissue manipulation decreases the oedema released into the effected muscular tissues. Active recovery is often a strategy suggested by medical personnel as it can be completed in the players own time. Active recovery can include simple activities such as a walk or a round of golf. This category consists of light movements which keep the body active, blood circulating and muscles engaged. Nonsteroidal anti-inflammatory drugs (NSAIDs) are a chemical combination designed at inhibiting the body's natural inflammatory response. They are usually used for impact injuries which have caused trauma to the internal structures and as a result a large amount of swelling has been produced. These anti-inflammatory products have become a popular method of treating athletes after high volume training sessions or contact sports. There are large ethical considerations when using these drugs and they are not as commonly used as other modalities as their repetitive use can cause health implications. Compression garments are a popular modern day method which is promoted globally through multi-national corporations. There is little evidence to support the use of elastic tights or elastic clothing as a post-exercise recovery method after recreational exercise. However, a study by Gill, Beaven and Cook (2006) found that wearing the compression garments 12 hours post-match enhanced recovery in rugby players when compared to passive recovery. Passive recovery usually occurs regardless of any additional recovery methods. It is the player's usual post-match routine which tends to include rehydrating, eating and showering. Stretching is a usual post exercise recovery method, whether it be active or passive. Once the stretch reflex reaction is inhibited, the muscular fibres and spindles can be lengthened. If appropriate techniques and positions are performed this can give a relieving effect on the shortened muscular tissue which can also have a positive effect upon the individual's mood. There are more recovery techniques available that utilise specialised equipment, but all aim to return the muscle tissue to its pre-exercise state. A final alternative and popular therapy is ice baths or water immersion. This involves the individual having the selected body part immersed in water of a cold or hot temperature, this can range from ice cold short cycles in water of five degrees Celsius or longer immersion times in water slightly warmer around 15 degrees Celsius.

2.8 Water Immersion Therapy

Water immersion therapy has become a popular recovery modality used in modern sport. Wilcock, Cronin and Hing (2006) state that the majority of water immersion therapy used are based upon unreliable or anecdotal information. He continues to add that the beneficial physiological changes that are made to the body are primarily attributed to the hydrostatic pressure of the water. Wilcock, Cronin and Hing (2006) define hydrostatic pressure as a pressure exerted by water on an immersed individual which can cause displacement of fluids within the tissues. Movement can occur from the outer regions to the central cavity where more available oxygenated blood can help metabolise any exercise by-products and thus transport a higher amount of substrates. The study also states that the waters up thrust effect caused by buoyancy can help reduce an individual's awareness of their fatigued state. There are four different recognised types of water immersion therapy; cryotherapy/cold water immersion (CWI), thermotherapy (TT), contrast immersion (CI) and water immersion (WI). TT is immersion in warm water which aims at increasing the temperature of the tissues. Bonde-Peterson, Schultz-Pedersen and Dragsted (1992) state that this increase in body temperature occurs at temperatures more than 36 degrees Celsius. The increase in temperature causes vasodilation of the local blood vessels and increased blood flow to the immersed areas (Cochrane, 2004). CI is when an athlete will sequentially change between a cold water and warm water immersion. Vaile, Gill and Blazevich (2007) state that the perceived effects of CI reduce edema accumulation through the pumping mechanism of vasoconstriction and vasodilation caused by the temperature change between immersions. This flushing effect is thought to reduce swelling and muscle spasm. However studies using contrast therapy (Myrer, Draper and Durrant, 1994; Myrer et al. 1997) in the form of CI and heat/ice packs concluded that both protocols failed to achieve a significant difference in intramuscular temperature. A study by Gill, Beaven and Cook (2006) concluded that their contrast immersion therapy protocol had a significant effect after a competitive game of rugby union, thus improving player's recovery. Higgins and Kaminski (1998) however state that due to the short immersion time between the hot and cold water intramuscular tissue temperature did not fluctuate significantly. It was concluded that the physiological effects therefore cannot be credited to the change in temperature.

2.9 Cold Water Immersion

CWI is a type of cryotherapy which includes a variety of specific treatments, these include ice gel, ice packs, ice massage, refrigerant gasses, ice chambers, contrast baths and CWI. Bleakley, McDonough and MacAuley (2004) believe that cryotherapy is the oldest practise of therapeutic treatment for soft tissue injuries while Rivenburgh (1992) states that there is evidence of using ice as a medical tool dating back to 460 BC. CWI is an increasingly popular modality (Calder, 2001) to treat individuals post-exercise. This may be because of the positive feedback from coaches, medical staff and the participants receiving the treatment that it has a facilitative effect on consecutive performances (Cochrane, 2004). CWI is thought to reduce the temperature of the skin, subcutaneous fat layer and the muscle tissue, however effects can vary depending on participants skinfold calliper readings (Myrer et al. 1997) and immersion time. If the muscle tissue is exposed to the water temperature long enough, this can cause the sympathetic nervous system to initiate vasoconstriction of the blood vessels in the immersed body area. Vasoconstriction of the vessels reduces blood flow to the area applied which decreases the amount of edema at the damaged muscle area, thus limiting the inflammatory response to damaged tissue (Brukner and Khan, 2012, p.139). Reduction of swelling is accompanied by a reduced sensation of pain due to lower levels of osmotic pressure caused by exudate upon nociceptors, a sensory neuron. Vasoconstriction achieves this by decreasing cell permeability, reducing the amount of diffusion into interstitial space from lymphatic and blood vessels (Leeder et al. 2011). The cooling effect decreases a nerves conduction velocity in superficial tissues, this has a positive effect as it decreases muscle spasms caused by an over firing of the muscular spindles in reaction to exercise (Cochrane, 2004). Decreased tissue temperature limits enzymatic reactions within the cellular structures such as neutrophils. Neutrophils are involved with the body's immune response to tissue injury by destroying damaged tissue (Butterfield, Best and Merrick, 2006). CWI has been found to make a positive effect to the recovery process, Eston and Peters (1999) had their participants immerse their exercised arm in cold water every 12 hours for a three day duration. There was an observed decrease in creatine kinase levels, stiffness and relaxed arm angle. Ingram et al. (2009) also found that CWI therapy was superior to contrast therapy and a control group who completed passive recovery after a repeated sprint test. Eston and Peters (1999) measured isometric strength in their study using an isokinetic dynamometer while and Ingram et al. (2009) tested isometric strength using a cable tensiometer. The present study utilised a hand held dynamometer (HHD) due to the portability, ease of application and they have been found to be a reliable and valid method of manual muscle testing (Le-Ngoc and Janssen, 2012; Wikholm and Bohannon, 1991). Conversely a study by Sellwood et al. (2007) found CWI treatment to be ineffective on alleviating DOMS outcome measures, including isometric measured on an isokinetic dynamometer. This questions what CWI protocol is optimal to alleviate DOMS symptoms.

2.10 Cold Water Immersion Protocol

Manipulating the immersion time, water temperature and time out of the water are all factors contributing to the CWI protocol. Variation in these factors has a large effect on the physiological outcome markers and the potential recovery of the participants. Participants were exposed to 15 minutes of CWI at a temperature of 15 degrees Celsius by Eston and Peters (1999) while Ingram et al. (2009) immersed their participants for two minutes for five sets at a temperature of ten degrees Celsius. Both studies had a positive effect upon the participants' recovery from their DOMS inducing exercise protocols, however it is difficult to attribute the positive outcomes to muscle tissue temperature change, or to the hydrostatic pressure. Research by Sramek et al. (2000) concluded that exposure to low temperatures had to be for a 10 minute duration in order for muscle tissue temperature to be significantly altered as this is the length it takes for vasomotor changes to become stable. This brings into question how Ingram et al. (2009) recovery protocol caused positive physiological changes to their participants. Positive effects could be attributed to the hydrostatic pressure effect of the water. Wilcock, Cronin and Hing (2006) believe the heightened pressure under the water's surface cause's diffusion of bodily fluids from the cellular space into the vascular system, this enhances recovery by removing swelling or oedema from the damaged tissue site. Conversely, Sellwood et al. (2007) subjected their participants to an eccentric loading protocol after which they received three one minute immersions in ice water at five degrees Celsius or the same protocol in tepid water (24 degrees Celsius). The outcome measures displayed that participants in the ice water group had a significant increase in pain 24 hours post-exercise and as a result, Sellwood et al. (2007) challenges the use of CWI as it provided no advantageous effects for pain, swelling or isometric strength. Crowe, O'connor and Rudd (2007) had their participants undertake a high intensity cycling protocol with an hour of recovery before repeating performance. Participants received 15 minutes of passive rest or 15 minutes of CWI at a temperature of 13 degrees Celsius. The study concluded that participants who received CWI had a performance decrement when compared to the group who passively recovered. This suggests that the CWI protocol used had a negative effect upon repeated anaerobic performance. The present study will only expose participants to a single bout of CWI therapy immediately after exercise, this method is also demonstrated in a study by Jakeman, Macrae and Eston (2009). Their protocol however made no beneficial effects to exercise-induced muscle damage. Quinn (2008) states there is no accurate or set protocol with regards to CWI although many studies have attempted to seek an optimum. This research will aim to provide more clarity as to which length of immersion is more effective at aiding recovery after high volume exercise.

2.11 Hypothesis

After evaluating various past and current literature the general hypothesis supports the beneficial physiological effects of CWI to alleviate symptoms associated with fatigue such as DOMS which are inhibitory to physical performance.

CHAPTER THREE
METHODOLOGY

3.1 Participants

The participants were selected from various rugby teams from university level teams. 11 Male rugby players (mean ± SD; age 22.4 ± 1.7 years, height 182 ± 5.9 cm, weight 93.9 ± 16.2 kg) volunteered to participate in the study, all of which met the selection criteria. The selection criteria demanded that all participants were an active part of their University team, they could not be currently injured and must have a minimum of two years of experience in resistive exercise training. All participants were asked to rest two days before the resistance exercise procedure (REP) to minimise variability. The days following the REP participants were asked to only carry out their standard passive recovery routine (food, walking and daily activities) and refrain from using other recovery aids such as compression garments.

3.2 Experimental Design

Participants were randomly allocated into one of three recovery groups. All groups were then instructed to complete an identical REP after carrying out a sufficient and specific warm up. Immediately after the REP two groups received a recovery intervention, the third group acted as the control group and received no recovery intervention. Two performance tests were carried out at 24 hours post-REP and 48 hours post-REP in order to decipher between the three recovery groups as to which was most effective at aiding recovery. Baseline test scores were classified as the participants’ optimum level of performance and were a comparison between 24 and 48 hour post-REP. Results collated from these tests were statistically analysed in order to compare and contrast the effectiveness of the recovery interventions.

3.3 Pilot study

A pilot study was conducted with participants that were not part of the main study. These results were not included in the study. No methods were altered after the pilot study was completed.

3.4 Participant Screening, Information and Informed Consent Sheets

Before any part of the study could begin participants were required to complete a physical activity readiness questionnaire (PAR-Q) (see Appendix C). This questionnaire is a screening tool which is designed to identify any participants who may have health problems which may contraindicate their participation in an exercise program. It contains brief questions about participant's general cardiovascular health and previous medical history. All participants received a participant information sheet (see Appendix A) which explains the research process. This included the aims of the study, a step by step procedure list, potential risks and how the study will benefit the participant. Finally, all participants were asked to sign a participant informed consent sheet (see Appendix B). The research proposal was granted by the Cardiff school of sport ethics committee before any participants were approached.

3.5 Anthropometric Measuring Equipment

Participant weight measurements were taken using SECA 770 electronic scales (Vogel and Halke, Hamburg, Germany) as they were able to measure to the nearest 0.1 kilogram (Penn et al. 2009). Height measurements were made using a portable stadiometer, SECA 321 (Vogel and Halke, Hamburg, Germany).

3.6 Fitness Testing Equipment

All fitness testing was completed inside the National Indoor Athletics Centre (NIAC) at Cardiff Metropolitan University. The REP procedure took place inside the diagnostics gym which was indoors minimising any external environmental factors. These controlled conditions allow for greater test-retest reliability as stated by Burnstein, Steele and Shrier (2011). Baseline testing included the measurement of counter movement jump height using the Smartspeed Jump Mat (Smartjump, Fusion Sport, Brisbane, Australia), this equipment was used for this measure as it has produced reliable and accurate results in other studies (Morton et al. 2014). Measurement of isometric strength was performed with a hand held dynamometer (HHD) (Biometrics, microFET2, Bolderweg, Netherlands). All isometric strength tests were performed on a massage table within the diagnostics gym to decrease variability and increase comfort of the participant while being tested. The REP was performed using a 20 kilogram Eleiko barbell (Olympic WL training bar, Eleiko Sport, Halmstad, Sweden). Load on the Eleiko barbell was increased using Eleiko weight plates (Olympic WL Training Discs, Eleiko Sport, Halmstad, Sweden).

3.7 Cold Water Immersion Equipment

CWI recovery interventions took place in NIAC. Fixed baths were used for the participants to be immersed within. Temperature of the water was regulated using ice from an adjacent ice machine in the same room as the fixed baths. Temperature was measured using a traditional mercury thermometer. Immersion durations were timed using a Fastime Stopwatch (01, Astopwatch Ltd., Ashby-de-la-Zouch, Leicestershire, UK).

3.8 Baseline Testing Protocol

Two performance tests were used as baseline testing methods. Baseline tests were performed before any fatiguing protocol. The first method was measuring participants counter movement jump (CMJ) height. This was done using the smartspeed jump mat. Participants were asked to step onto the mat, place their hands onto their hips to reduce upper body contribution and when ready perform a maximal effort vertical jump with an early fast countermovement/dip. This process was repeated three times with one minute of rest in between each jump. Isometric strength tests were performed using a HHD. Measurements were taken at the knee extensors, flexors and hip extensors on both left and right limbs. Positions used in this study to measure isometric strength were replicated from studies which also utilised a HHD (Andrews, Thomas and Bohannon, 1996; Bohannon, 1986; Thorborg et al., 2010). To measure knee extensors participants were sat on the massage table with their hips and knees flexed to 90° with their hand resting on their lap. The HHD was placed proximal to the malleoli of the ankle on the anterior surface while the participant was stabilized by an assistant at the shoulders. The same position and stabilization was performed for the measurement of knee flexors but with the HHD placed proximally to the malleoli but on the posterior surface. Hip extension was measured with the client lying in a prone position on the massage table, the back and hip in a neutral position and the HHD placed five centimetres proximal to the knee joint line, at the posterior thigh. Each limb was tested three times for each position and was separated by 30 seconds rest in between maximal repetitions.

3.9 Warm-Up

A five minute specific warm up was performed prior to the REP (see Appendix D). The warm up consisted of dynamic movements of muscles within the squat pattern and aimed at raising participants hear rate and mobilising and potentiating the neuromuscular system.

3.10 Resistance Exercise Procedure

The REP consisted of the participants completing a total of 100 barbell back squats through a repetition range of ten reps for ten sets. Each set of ten was separated by one minute rest. The squat movement began with the barbell resting on their shoulders in a standing position, feet at roughly shoulder width apart with toes slightly externally rotated and knees fully extended. A simultaneous triple flexion then took place at the hips, knees and ankles to allow the participant to descend to a depth where their knees were parallel with their knees. From this bottom position a forceful triple extension at the same joints occurred, whilst maintaining a tall upright upper torso posture to return to the starting position. Participants were asked to maintain a three to one ratio speed on the descent and ascent of the squat as this allowed for a larger amount of force to be applied to the muscles under higher tension (Proske and Morgan, 2001). This increase in the amplitude and length of stretch was implemented in order to fatigue participants as it is accepted that eccentric exercise causes immediate and delayed inhibited performance (Morgan and Allen, 1999).

3.11 Cold Water Immersion Protocols

All CWI therapy took place within the fixed bath room in NIAC. All Participants were walked from the diagnostics gym to the fixed baths room and began their recovery intervention within two minutes of the REP. The first recovery group, group 1, followed a similar protocol utilised by Eston and Peters (1999). Participants (4) were immersed in the fixed baths for a duration of 15 minutes with the water temperature maintained at 10° Celsius by the addition of ice. The second recovery group, group 2, (4) were subjected to five two minute immersions at a temperature of 10° Celsius with a one minute sitting period between immersions, this is a protocol employed in a study by Ingram et al. (2009). The control group, group 3, (3) were asked to sit for a 15 minute period after the REP and had no recovery intervention in the following 48 hours.

3.12 Data Analysis

Data collected from the participants was then statistically analysed using IBM SPSS Statistics (version 20). This software was provided by Cardiff Metropolitan University and was used to analyse the recorded data in order to observe if there was a significant difference between the intervention protocols and control groups recovery from exercise. The software was used to run a three-way factorial ANOVA across the seven variables recorded at the three separate testing times. Significance was recognised at <0.05.

CHAPTER FOUR
RESULTS

4.1 Introduction

This chapter will display results from the seven different performance variables at the three different testing times. Results will demonstrate whether the recovery interventions, a 15 minute immersion or five two minute cyclical immersions made a significant difference to recovery for rugby players recovering from a high volume squat protocol when compared to a control group. Significance was accepted at $P < 0.05$.

4.2 Countermovement Jump

Table 1. Mean values of each recovery group's counter movement jump (CMJ) height at baseline, 24 hours post-REP and 48 hours post-REP (mean ± SD).

Recovery Group	Testing Times	Counter Movement Jump Height (cm)
Group 1	Baseline	46.36 ± 5.10
	24 Hours Post REP	38.52 ± 5.96
	48 Hours Post REP	43.54 ± 5.47
Group 2	Baseline	42.88 ± 9.68
	24 Hours REP	37.66 ± 9.09
	48 Hours Post REP	38.71 ± 9.16
Group 3	Baseline	37.00 ± 4.82
	24 Hours Post REP	32.71 ± 5.33
	48 Hours Post REP	32.71 ± 5.20

A three way factorial ANOVA was performed to show if the recovery interventions made a significant difference to CMJ height in comparison to the control group after the REP over a 48 hour recovery period. Results showed no significant difference ($P > 0.05$) at 24 hours post REP for group one (F = 1.5, $P > 0.659$), group two (F = 1.0, $P > 0.822$) when compared to the control group.

At 48 hours post REP the results show that group ones recovery intervention made a small difference to CMJ height. However when compared against the control group they were not significant (F = 1.5, $P > 0.236$). Group two also showed no significant difference (F = 1.0, $P > 0.889$) in CMJ height in comparison to the control group. When comparing both recovery interventions against each other at both 24 and 48 hours post REP, there was no significant difference between the varied protocols ($P > 1.00$).

4.3 Knee Extensor Strength

Table 2. Mean values of each recovery group's knee extensor (KE) strength at baseline, 24 hours post-REP and 48 hours post-REP (mean ± SD).

Recovery Group	N	Testing Times	Left KE Strength (N)	Right KE Strength (N)
Group 1	4	Baseline	451.17 ± 107.28	458.58 ± 90.02
		24 hours post	336.25 ± 109.98	343.03 ± 89.06
		48 hours post	422.75 ± 97.19	407.77 ± 77.45
Group 2	4	Baseline	541.68 ± 164.69	536.90 ± 148.15
		24 hours post	436.58 ± 146.12	450.18 ± 145.20
		48 hours post	454.15 ± 151.99	432.23 ± 105.41
Group 3	3	Baseline	441.87 ± 74.78	457.33 ± 91.06
		24 hours post REP	362.23 ± 47.00	365.20 ± 45.48
		48 hours post REP	368.40 ± 44.13	369.63 ± 43.79

A three way factorial ANOVA was performed to show whether the recovery interventions made a significant difference to KE strength in comparison to a control group over a 48 hour recovery period. The results show that group one's recovery intervention did not make a significant difference to KE strength 24 hours post-REP to the left leg (F = 0.7, $P > 1.00$) or the right leg (F = 0.6, $P > 1.00$) when compared to the control group. Group one's intervention also failed to make a significant difference to KE strength at 48 hours post-REP on both the left leg (F = 0.7, $P > 1.00$) and right leg (F = 0.6, $P > 1.00$) when compared to the control group. The recovery intervention followed by group two failed to make a significant difference to KE strength at 24 hours post-REP to the left leg (F = 0.8, *P* > 1.00) and right leg (F = 1.1, *P* > 0.983). Recovery group two's intervention also failed to make a significant difference to KE strength at 48 hours post-REP on both left (F = 0.8, *P* > 1.00) and right (F = 1.1, *P* > 1.00) legs. Non-significant results were also found when comparing group one against group two at both 24 hours post-REP (left- *P* > 0.750; right- *P* > 0.581) and 48 hours post-REP (left- *P* > 1.00; right- *P* > 1.00) for KE strength.

4.4 Knee Flexor Strength

Table 3. Mean values of each recovery group's knee flexor (KF) strength at baseline, 24 hours post-REP and 48 hours post-REP (mean ± SD).

Recovery Group	N	Testing times	Left Knee Flexor Strength (N)	Right Knee Flexor Strength (N)
Group 1	4	Baseline	327.15 ± 95.79	331.82 ± 93.55
		24 hours post	280.68 ± 81.98	277.33 ± 83.72
		48 hours post	313.85± 95.87	314.37 ± 97.74
Group 2	4	Baseline	477.40 ± 112.19	485.83 ± 134.64
		24 hours post	363.53 ± 101.86	374.85 ± 113.66
		48 hours post	386.80 ± 116.50	398.60 ± 105.30
Group 3	3	Baseline	382.43 ± 76.34	390.20 ± 88.2
		24 hours post	331.43 ± 43.50	325.20 ± 66.54
		48 hours post	331.40 ± 61.68	332.87 ± 67.87

A three way factorial ANOVA was performed to show whether the recovery interventions had a significant effect on KF strength in comparison to a control group over a 48 hour recovery period. The statistical analysis showed that group one's recovery intervention did not make a significant difference to KF strength performance at 24 hour post-REP on both left (F = 2.4, *P* > 1.00) and right (F = 2.0, *P* > 1.00) legs, and no significant difference was found at 48 hour post-REP on both left (F = 2.4, *P* > 1.00) and right (F = 2.0, *P* > 1.00) legs when compared to a control group. The intervention followed by group two when compared with a control group did not make a significant difference to KF strength at 24 hours post-REP on both left (F = 1.0, P > 1.00) and right (*F* = 1.1, P > 1.00) legs. Non-significant results were produced at 48 hours post-REP for group twos KF strength on both left (*F* = 1.0, P > 1.00) and right (*F* = 1.1, P > 1.00) legs. When comparing both recovery interventions to each other at 24 hours post-REP non-significant results were obtained for KF strength on both legs (left- P > 0.587; right- P > 0.524). Non-significant results were also produced when comparing group one and two 48 hours post REP KF strength on both left (P > 0.961) and right (P > 0.726) legs.

4.5 Hip Extensor Strength

Table 4. Mean values of each recovery group's hip extensor (HE) strength at baseline, 24 hours post-REP and 48 hours post-REP (mean ± SD).

Recovery Group	N	Testing times	Left HE Strength (N)	Right HE Strength (N)
Group 1	4	Baseline	316.78 ± 67.48	309.05 ± 66.14
		24 hours post	258.58 ± 56.06	236.84 ± 34.32
		48 hours post	300.85 ± 61.84	290.99 ± 65.41
Group 2	4	Baseline	445.03 ± 144.54	419.15 ± 124.60
		24 hours post	371.65 ± 122.07	343.35 ± 107.74
		48 hours post	386.58 ± 138.73	365.78 ± 120.22
Group 3	3	Baseline	357.77 ± 26.53	385.43 ± 25.82
		24 hours post	302.30 ± 15.61	320.57 ± 4.27
		48 hours post	311.83 ± 10.01	315.87 ± 15.27

A three way factorial ANOVA was performed to determine whether the recovery interventions had a significant effect on HE strength over a 48 hour recovery period when compared to a control group. The analysis showed that at 24 hours post-REP group one's recovery intervention failed to make a significant difference to HE strength in both left (F = 1.8, P > 1.00) and right (F = 1.7, P > 0.457) hips when compared to a control group. It also did not make a significant effect at 48 hours post-REP in both left (F = 1.8, P > 1.00) and right (F = 1.7, P > 1.00) hips. Group two's recovery intervention did not make a significant difference to HE strength at 24 hours post REP on both limbs (left- F = 1.9, P > 0.91; right- F = 2.6, P > 1.00) when compared to a control group. The same recovery intervention failed to make a significant difference to HE strength 48 hours post-REP in both left (F = 1.9, P > 0.972) and right (F = 2.6, P > 1.00) hips when compared to the control group.

When comparing the recovery intervention groups against each other at 24 hours post-REP, there was not a significant effect to HE strength to either left ($P > 0.267$) or right ($P > 0.184$) hips. Non-significant results were also produced when comparing group one and group two HE strength 48 hours post-REP in both left ($P > 0.688$) and right ($P > 0.733$).

CHAPTER FIVE
DISCUSSION

5.1 Introduction

This study compared two different CWI protocols success in aiding recovery after a high volume squat session with male, university level rugby players when compared to a control group. Considering the hypothesis proposed in chapter two, the null hypothesis has been accepted as no significant differences were produced ($P > 0.05$). Comparisons were evaluated throughout the 48 hour post-REP period between a 15 minute immersion group, a group who endured five two minute immersions and a passive recovery (control) group. Seven performance variables were statistically analysed at three separate time periods to examine the effect the two different recovery protocols had on each variable compared to the control group. Results show that both recovery protocols had no significant effect on all seven performance variables throughout the 48 hour recovery period. This section will discuss the key findings of the study, limitations and strengths of the design, practical implications of the results and finally directions for future research will be considered.

5.2 Key Findings

The fatigue protocol utilised in this study was a high volume squat procedure used in a study by Byrne and Eston (2002). The squat protocol resulted in a successful impairment of muscular function as all groups mean scores in CMJ height and isometric strength tests were reduced 24 hours post-REP, as were the participants in the study by Byrne and Eston (2002). However, Byrne and Eston (2002) conducted their study using healthy participants while the present study used sport specific trained participants, for this reason the present studies work load and intensity of the fatigue protocol was increased to deliver a larger stimulus. The resulting decline in performance at 24 hours post-REP can be attributed to the DOMS symptoms produced by strenuous exercise (McHugh et al., 1999;

Cheung Hume and Maxwell, 2003; Connolly, Sayers and McHugh, 2003). The recovery interventions did not have a significant effect ($P > 0.05$) on CMJ height after CWI therapy. Both recovery groups in the present study failed to significantly aid recovery and replicate participants' baseline performance levels. The results from the present study are in conjunction with a study conducted by Roswell et al. (2009) and Jakeman, Macrae and Eston (2009). Their studies also found that a single episode of CWI failed to make a significant effect to recovery after a high volume, lower body protocol. Bailey et al. (2007) however also used a single ten minute immersion as their recovery intervention and concluded that CWI applied as a single bout had a positive effect upon factors associated with muscle damage. Bailey et al. (2007) conversely used healthy/active participants as their population and only found significant effects to recovery in perception of muscle soreness up to 48 hours post-exercise and a lower decrement in maximal voluntary contraction (MVC). Bailey et al. (2007) however question the use of MVC as a reliable tool for the measurement of exercise-induced muscle damage as it is more sensitive to decrements in function when compared to other performance measures such as jump height or sprinting time. Future studies should include a perception of soreness measure to assess individual participant's response to CWI therapy. This decrement in CMJ performance could be attributed to the damage of the musculature structure caused by the elongated eccentric portion to the squat pattern increasing the time under tension the muscle was subjected to and causing a prolonged impairment to performance (Proske and Morgan, 2001).

Isometric strength tests were performed using a HHD in positions demonstrated by previous studies (Andrews, Thomas and Bohannon, 1996; Bohannon, 1986; Thorborg et al., 2010). Strength readings were taken of the knee extensors, knee flexors and hip extensors of both left and right limbs during the 48 hour recovery period. Both recovery interventions failed to make a significant difference ($P > 0.05$) to isometric strength performance in all measured muscle groups. These results comply with findings by Eston and Peters (1999) that CWI therapy failed to make any facilitative effects to strength loss over a 48 hour recovery period. Although the differences in strength performance were non-significant in the present study at 48 hours post-REP, Eston and Peters found that their participants returned to their baseline strength values at 72 hours post exercise, their results were also non-significant. This suggests that mathematical significance is only a reflection of a statistical view and not a practical one which can be subjective to an individual's recovery. If performance testing was extended to the full 96 hour recovery window suggested by Cleak and Eston (1992) perhaps significant results would have been obtained. However, Eston and Peters (1999) exposed their subjects to multiple immersions compared to a single immersion in the present study.

Ingram et al. (2009) also found no significant effects from CWI on isometric strength performance, it was however found that CWI had a positive effect on the perception of muscle soreness at both 24 hours post-exercise and 48 hours post-exercise. This again reiterates that CWI may only effect a person's perception of their pain as there were no significant effects on physiological markers of muscle damage. The present study adds to the collection of data that supports CWI as having no significant effects on isometric strength. The present study utilised a HHD as an isometric strength measure, Ingram et al. (2009) used a cable tensiometer and Eston and Peters (1999) used an isokinetic dynamometer. This provides both varied and reliable data as multiple types of equipment have been used including an isokinetic dynamometer which is believed to be the most accurate method of muscle testing. This is due to assessor strength and participant stabilization not being a reliability factor as it is controlled by the fixed machine (Le-Ngoc and Janssen, 2012). Decrements in strength performance are expected due to cross sectional area damage after high volume exercise (Cheung, Hume and Maxwell, 2003).

5.3 Limitations

5.3.1 Sample Size

The participant sample size is a large limitation within the present study. Only having 11 subjects limits the amount of statistical power the results can have as there are less subjects to detect the desired effects of the separate recovery protocols. Limited sample size leaves the study at risk of making a type II error, failing to detect an effect that is present. Small subject numbers make the results of this study harder to apply to the population which is being investigated. Bailey et al. (2007) used 20 subjects in their study and found significant results allowing for further, reliable generalization of results.

5.3.2 Dependent Variables

A further limitation of the study was that only performance variables were used as dependant variables. Although this makes the results applicable to sport specific skills, it fails to recognise the bio-chemical and psychological effects that high volume exercise can have upon participants. By including a wider range of dependant variables a more comprehensive and detailed investigation into the effect of the recovery protocols can be conducted. Examples of these variables are creatine kinase blood levels, relaxed joint angles, limb circumference measurements, visual analogue scale, muscle soreness Likert scale and descriptor differentials scale (DSS). The inclusion of these variables would allow the recovery process to be assessed in a bio-psychological approach. This is important because recovery modalities are heavily influenced by an athlete's physiological response and their psychological perception. Ingram et al. (2009) found that although their CWI protocol did not make a significant difference to creatine kinase and inflammation markers recorded in the blood, it did have a significant difference on muscle soreness ratings on a Likert scale which is judged by a participant's individual perception of the pain. Similar results were also found in Bailey et al. (2007) who reported a significant difference from muscle soreness ratings one, 24 and 48 hours post-exercise in the CWI group when compared to a control group. The use of a pain perception variable would have allowed the present study to assess whether the CWI protocols effectiveness varied in this variable when compared to a control group.

5.3.3 Hand-Held Dynamometer

Measuring isometric strength with a HHD has good reliability when used by an experienced user (Le-Ngoc and Janssen, 2012). It is however suggested that tester strength can vary the total force recorded by up to 30% (Wikholm and Bohannon, 1991). When combining tester strength with the inexperience of the tester raises questions into the reliability of the strength scores obtained in the present study. The positions which the participants were measured during the isometric strength tests are a limitation as hip extension was measured in a prone position, using a short lever. However in a study by Thorborg et al. (2010) the standard error of measurement was higher in a short lever in this position compared to a long lever. A long lever method may provide more accurate results when measuring hip extension. To improve reliability alternative muscle assessment methods should be used such as an isokinetic dynamometer to reduce variability of results caused either by tester strength or if a subject overcomes the strength of the tester (Wikholm and Bohannon, 1991).

5.3.4 Fatigue Protocol

The high volume squat protocol employed in the present study may have been too intense for the participants. A high volume session such as the one performed is usually found in a pre-season general preparation block of training. Most teams at the point in the season at which the study was conducted would perform smaller volumes with a larger focus on power and strength, moving large weights in a forceful fast motion (Duthie, 2006). This may explain the large decrement in performance variables and the inability for the recovery interventions to make a significant difference. In order to measure the intensity of the REP a rate of perceived exertion (RPE) scale should be used to record participant's effort throughout the exercise procedure as used by Ingram et al. (2009).

A key limitation to the present study was that there were no variables to measure the participant's perception of DOMS throughout the 48 hour recovery period. A muscle soreness Likert scale DSS or visual analogue scale may have presented significant effects as shown in previous studies (Ingram et al., 2009; Bailey et al., 2007). This information would be valuable to medical staff and practitioners as the perception of an athlete's pain can differ regardless of physiological markers. The use of this type of variable may help to differentiate as to which recovery modality is more suited to an individual. Exposure to both recovery protocols in a cross over design may have revealed significant results as one protocol may be more individually suited to an athlete's personal recovery process.

5.4 Strengths

A strength of this study is that it can be replicated in most team settings in different sports. The equipment used was reliable, cheap and portable making the testing procedure simple to replicate in different settings. From the results recorded form the study, it is valid for the subjects involved that the respected recovery interventions which they were exposed to were ineffective at alleviating fatigue symptoms after a high volume session. This may be useful in pre-season phase where increasing muscle cross sectional area or muscle mass is achieved through higher volume sessions (Duthie, 2006) allowing coaches to review their recovery methods. The recovery window of 48 hours used in this study is a realistic time scale in-between training sessions for university level athletes. The CWI protocols only consisted of a single immersion, immediately after exercise. This can be considered realistic for amateur level rugby players as time after training sessions may be limited by employment or educational commitments. A protocol employed by Eston and Peters (1999) of using CWI every 12 hours would not be achievable for a study of this level. The present study only included university level rugby players, the results from the study may be useful to coaches and practitioners involved with this population in order to review their recovery modalities. The present study also gives data on a sport specific trained population in comparison to a study by Bailey et al. (2007) who used “healthy men volunteers” as participants. Results from the present study would not applicable to the population tested in by Bailey et al. (2007).

This research is effective at eliminating these recovery modalities in this specific population for the high volume stimulus. Data recorded in the present study narrows the spectrum for discovering an optimal protocol for CWI therapy when treating rugby union players.

5.5 Practical Implications

As water immersion is growing as a popular recovery modality (Wilcock, Cronin and Hing, 2006) it is important to produce reliable scientific studies aimed at optimising the recovery process. Knowledge of protocols which can or cannot make a significant difference to recovery are important to athletes, coaches and practitioners. This would allow for the periodization of each athlete or teams training to be specifically tailored to overload the players, allow them to recover adequately and then observe a subsequent improvement to the level of performance. This study does not support the use of the two CWI protocols employed after high volume lower body training, this suggests that other recovery techniques should be investigated. However, due to the large amount of limitations in the study design, more detailed research with the use of more physiological and psychological variables should be conducted. Information from the present study informs practitioners working with the tested population that the two CWI protocols performed are ineffective at aiding fatigue recovery after a high volume, lower body resistance session. Information is important for pre-season or rehabilitation periods for players as heightened volume of training stimulus is a common occurrence in this phase of a season.

5.6 Future Research

As past literature is largely based on anecdotal evidence for the effectiveness of CWI therapy on the alleviation of DOMS symptoms, future studies should include both qualitative and quantitative data. This will help to establish whether the effects of CWI are down to the perception of the individual, the physiological effects that CWI is thought to achieve or a combination of both. Future studies should investigate the effects of CWI therapy on the recovery from training which induces peripheral fatigue in comparison to training which induces central fatigue (Froyd, Millet and Noakes, 2013). This would help to evaluate CWI therapies effect on structural damage and the effect on neural properties stimulated in strength training.

Due to the large variety of protocols used throughout past and current literature it is difficult to make clear comparisons. Research should be focused on identifying an optimum immersion length and temperature. For the population investigated in this study the use of

CWI therapy after a simulated game situation or competitive game should be investigated. This will allow for more sport specific physiological demands such as contact and collisions to be taken into account when recovering from or between games. Inclusion of a game specific fatigue protocol whilst employing a similar experiment design should be combined with the use of a single psychological variable, such as perception of pain measured on a visual analogue scale, a single physiological variable such as creatine kinase blood levels and a single performance variable such as vertical jump performance. Results would indicate whether the CWI protocols utilised in the present study were effective at alleviating physiological fatigue markers, psychological perception of participant's pain and restoring pre-exercise performance levels.

CHAPTER SIX
CONCLUSION

6.1 Conclusion

To conclude the present study, no significant effects were found between a 15 minute CWI protocol and five cyclical two minute CWI in comparison to a control group at alleviating DOMS symptoms and restoring physical performance. The results however did not indicate a negative effect upon recovery from either CWI protocol, only no significant effect was detected in the performance variables in comparison to the control group. A key weakness of the present study was the limited sample size and that only performance measures were used as dependant variables. It is recommended for future research for a larger sample size to be subjected to two varied CWI protocols and to employ a cross over design, allowing both recovery groups to be exposed to each recovery intervention. Future research should use physiological and psychological variables in conjunction with performance measures to allow for a more comprehensive assessment of each CWI protocols effectiveness on the participants. Results obtained utilising these variables allows for participants pain perception, physical reaction and performance restoration to the CWI therapy to be analysed more accurately and view any correlations across the three types of dependent variables. Data collected in the present study can be used to direct athletes, coaches and medical practitioners to search for alternative CWI protocols after high volume resistance exercise when treating university level male rugby players.

CHAPTER 7
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APPENDICES

APPENDIX A

PARTICIPANT INFORMATION SHEET

UREC reference number:

Title of Project: The effect of cold water immersion on fatigue recovery and strength performance

Participant Information Sheet

Background

This research project is an attempt to discover the effect that cold water immersion therapy has upon fatigue recovery and strength performance when performed for varied durations.
In brief, the research is concerned with discovering an optimal length for cold water immersion therapy to aid the recovery between training sessions for male rugby union players.
There are two areas the research will examine:

(i) Whether five two minute cyclic immersions or 15 minutes of cold water immersion therapy is more effective

(ii) The therapy's effect upon recovery for performance measures

Why you have been asked

As a male rugby union player, recovery time between training sessions needs to be optimal in order for maximal effort to be applied during practice sessions. You have been asked as it is believed you will benefit as a result.

What will happen if you agree to participate in the research project?

If you agree to participate in the research project there are 3 main things that will happen.

1. You will be asked to visit the National Indoor Athletics Centre (NIAC). You will have your body measurements and information (weight, height, age) taken and asked to complete an isometric strength test to assess the lower limb muscles involved and a vertical jump test.
2. You will be asked to complete a resistance exercise procedure in order to induce fatigue symptoms.
3. Immediately after your testing, you will be asked to enter an ice bath which will be held in NIAC. Depending as to which group you are randomly assigned to, you will be subjected to either or no treatment,   or 15 minutes of this treatment.
4. You will be asked to return 24 hours post-exercise in order for the lower limb strength and jump testing to be repeated.
5. Finally, you will be asked to return to the same destination 48 hours post-exercise to repeat the same lower limb strength and jump testing.

Are there any risks?

The risks involved with the study mainly revolve around your reaction to the cold water immersion therapy. The water will be maintained at either approximately 10°C in order to gain the expected effects predicted to the recovery process. If you have had any previous bad reactions to either ice baths or the cold, inform the researcher and you will be withdrawn from the study. At any point during the study you feel like you do not want to be part of the research inform the researcher as soon as possible.

Your rights

You have the right to exit research process at any time.

What happens to the results of the research?

The results obtained from the study will be recorded and coded by the researcher to compare your scores with other participants. The information will be presented within the delegated recovery groups with other participants but no description will identify any of the participants. The research will be collated and presented to Cardiff Metropolitan University in the form of a 10,000 word research project.

Are there any benefits from taking part?

Yes, you will undergo a fatiguing resistance exercise procedure which has been deemed beneficial for rugby union players. The recovery process may also identify an optimal process for you to recover from a training session in order to perform at a higher level in your next session or possible competitive game.

How your privacy will be protected

All the information recorded from the study will be stored securely and digitally while the data is being assessed. After the data has been analysed the participants' information will be destroyed.

Further information If you have any further questions about the study please contact the researcher.

Daniel George
Email: st20002083@outlook.cardiffmet.ac.uk Mobile: 07983872199

APPENDIX B

PARTICIPANT INFORMED CONSENT SHEET

UWIC PARTICIPANT CONSENT FORM

UREC Reference No:
Title of Project: The effects of varied cold water immersion protocols on recovery and repeated performance measures in male rugby players

Name of Researcher: Daniel George

Participant to complete this section: Please initial each box.

1. I confirm that I have read and understand the information sheet dated ………. for this research study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐

2. I understand that my participation is voluntary and that it is possible to stop taking part at any time, without giving a reason. ☐

3. I also understand that if I participate in the study I have the right to exit at any time. ☐

4. I understand that information from the study will be used as part of a research project but my identity will not be revealed. ☐

5. I agree to take part in this research project. ☐

Name of Participant___________________

____

____
Signature of Participant
Date

APPENDIX C

PHYSICAL ACTIVITY READINESS QUESTIONNAIRE (PAR-Q)

Name: **DOB:**

Physical Activity Readiness Questionnaire (PAR-Q) If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you significantly change your physical activity patterns. If you are over 69 years of age and are not used to being very active, check with your doctor. Common sense is your best guide when answering these questions. Please read carefully and answer each one honestly: check YES or NO.

Please circle either YES or NO

	Yes	No
1. Has your doctor ever said you have a heart condition and that you should only do physical activity recommended by a doctor?		
	Yes	No
2. Do you feel pain in your chest when you do physical activity?		
	Yes	No
3. In the past month, have you had a chest pain when you were not doing physical activity?		
	Yes	No
4. Do you lose you balance because of dizziness or do you ever lose conciousness?		
	Yes	No
5. Do you have a bone or joint problem (for example, back, knee, or hip) that could be made worse by a change in your physical activity?		
	Yes	No
6. Is your doctor currently prescribing medication for your blood pressure or heart condition?		
	Yes	No
7. Do you know of any other reason why you should not do physical activity?		

If yes, please comment:

YES to one or more questions:

You should consult with your doctor to clarify that it is safe for you to become physically active at this current time and in your current state of health.

NO to all questions:

It is reasonably safe for you to participate in physical activity, gradually building up from your current ability level. A fitness appraisal can help determine your ability levels.

I have read, understood and accurately completed this questionnaire. I confirm that I am voluntarily engaging in an acceptable level of exercise, and my participation involves a risk of injury.

Signature

Print name

Date

Having answered YES to one of the above, I have sought medical advice and my GP has agreed that I may exercise.

Signature

Date

Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the 7 questions.

APPENDIX D
WARM-UP PROTOCOL

Exercise	Sets	Repetitions
Lateral lying leg raises	2 (each side)	10
Side lying banded clams	2 (each side)	10
Sumo Squats	2	10
Inchworms	2	10
Spiderman hip stretch	2 (each side)	10