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CARDIFF METROPOLITAN UNIVERSITY
Prifysgol Fetropolitan Caerdydd

CARDIFF SCHOOL OF SPORT

DEGREE OF BACHELOR OF SCIENCE (HONOURS)

SPORT CONDITIONING, REHABILITATION AND MASSAGE

TITLE
THE COMPARISON BETWEEN COLD WATER IMMERSION AND MASSAGE ON THE ALLEVIATION OF DELAYED ONSET MUSCLE SORENESS

(Dissertation submitted under the discipline of SCRAM)

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Acknowledgements

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Abbreviations

DOMS – Delayed Onset Muscle Soreness
DDS – Descriptor Differential Scale
VAS – Visual Analogue Scale
NSAIDs – Nonsteroidal Anti-Inflammatory Drugs
Abstract

Background: Delayed onset muscle soreness (DOMS) will give an athlete feelings of pain and tenderness and physiological effects of muscle stiffness, deep muscle aching, decrease in muscular force production and range of movement. From this there is a need for recovery strategies to alleviate DOMS, there are many interventions suggested to treat DOMS however there is limited support in the interventions aiding recovery and enhancing performance. There are very few published articles which investigated the comparison between cold water immersion and sports massage on the alleviation of DOMS, thus there is a lack of scientific support.

Aim: The aim of this study was to compare the effects of cold water immersion and sports massage on the alleviation of DOMS after eccentric exercise.

Method: Eight trained female (Mean ± SD; age 20.65 ± 1.06 years, height 167.3 ± 6.58 cm, weight 67.81 ± 6.63 kg) university level football players from Cardiff Metropolitan University participated. Immediately after an eccentric exercise session cold water immersion or massage was applied to the participants. Lower limbs were submerged for eight minutes in 10-15°C water and the massage variable was 16 minutes with 8 minutes of effleurage on both left and right quadriceps. The study had a crossover design therefore the participants experienced both variables.

Results: Results were statistically analysed using a dependant t-test, results indicated that there was no significant difference between cold water immersion and sports massage on the alleviation of DOMS (p>0.05).

Conclusion: The present findings suggest that an eight minute cold water immersion compared to a 16 minute massage have no significant difference. Further research is required to support cold water immersion and massage physiological effects on the alleviation of DOMS for recovery purposes.
CHAPTER ONE:
INTRODUCTION
1.0 Introduction

There is a great importance for adequate recovery for any athlete; optimal performance will not be reached if the athlete has not recovered fully. Also for optimal performance the athlete needs to balance training and competition with suitable recovery (Kuipers, 1998). Recovery is often over looked by many trained or untrained athletes and their coaches; however recovery and performance should have a balanced relationship with all training programs (Kuipers, 1998). Inadequate recovery after intensive exercise which could induce muscle damage which can produce physiological consequences; one consequence is DOMS (Kellmann, 2002). DOMS is suggested to cause a decrease in performance due to the physiological effects on the soft tissues after intense eccentric exercise (Ernst, 1998), this is further discussed in chapter two. Decreased muscle function is one of the key findings to cause detriment to an athlete’s performance; this loss in muscle function is a physiological effect from DOMS. The many implications DOMS causes an athlete has led to suggest that prevention and the alleviation of DOMS is off high priority for any athlete.

Recovery strategies have been devised to alleviate the physiological effects and perception of DOMS; these strategies include stretching, massage, anti-inflammatories, cold water immersion and exercise. However none of the recovery strategies mentioned has provided results which suggest the full alleviation of DOMS (Gulick, Kimura, Sitler, Paolone & Kelly, 1996). There is an increase in the use of cold water immersion and sports massage, however research on both of these recovery strategies have conflicting results when associated with DOMS (Cheung, Hume & Maxwell, 2003). For both strategies there were promising results in the decrease of muscle soreness (Hilbert, Sforzo, & Swensen, 2003; Rowsell, Coutts, Reaburn & Hill, 2009) however there was little support for improving the loss of muscle function (Farr, Nottle, Nosaka & Sacco, 2002).

On the other hand there is limited research in the comparison between recovery strategies on alleviating DOMS. Research into comparing strategies, for example cold water immersion and sports massage, can contribute to athletes, coaches and therapist’s knowledge. It would provide an answer into what are the best strategies for alleviating DOMS. This research aims to decrease the gap in literature and to find a result which indicates which strategy has greater alleviation on DOMS.
1.1 Aims and Objectives
The aim of this study was to investigate and assess the effectiveness of cold water immersion compared to sports massage on the alleviation of DOMS. The objective was to conclude which recovery strategy between the two had a greater outcome on the perception of DOMS.

1.2 Study Rationale
Sports massage and cold water immersion are suggested to be effective recovery treatment methods for athletes; however there is lack of scientific evidence supporting these methods for the alleviation of DOMS. There is an increasing need to understand how DOMS is obtained and how to alleviate the symptoms for athletes; this is because athletes need to recover quicker. For example the Cardiff Metropolitan University Women’s football squad train four times a week and perform twice a week, therefore there is a need for the athletes to recover quickly in time for the next training session or match.

1.3 Hypothesis
H0- It is hypothesised that following the cold water immersion and sports massage variables, there will be no significant difference between the two in the perceived alleviation of DOMS.

H1- It is hypothesised that following the two variables, there will be a statistical significant difference between the two in the perceived alleviation of DOMS, with cold water immersion having a greater effect.
CHAPTER TWO:
LITERATURE REVIEW
2.0 Delayed Onset Muscle Soreness (DOMS)

After intensive exercise an athlete may be subject to DOMS, this will give the athlete feelings of pain and tenderness and physiological effects of muscle stiffness, deep muscle aching, decrease in muscular force production and range of movement. For any athlete such feelings are undesirable, it is suggested that DOMS can be a negative result of poor recovery after exercise (Szymanski, 2001). Perception of DOMS starts eight to twelve hours post eccentric exercise, however the effects associated with DOMS will peak at 24-72 hours (Polwmans & Smith, 2008). It has been stated that the effects of DOMS will disperse five to seven days after exercise; however this can be problematic for an athlete who trains and competes on a regular basis during the week (Szymanski, 2001). Physiological problems such as muscle stiffness and decreased muscular force production can be detrimental to an athlete and optimum levels cannot be reached during exercise (Ernst, 1998). Therefore there is a great need for effective recovery strategies to alleviate the effects of DOMS.

2.0.1 Eccentric Exercise

Eccentric movements involve a muscle group contracting, yet whilst contracting the muscle lengthens due to the greater resistance being applied to the muscle (Cash, 1996). The fibres involved with this type of movement are placed under a significant shear force which creates tension and breaks fibrous adhesions (Cash, 1996). It has been stated that to induce DOMS eccentric exercises of a sufficient intensity and duration are to be performed by the athlete; it has been proposed to cause damage to the muscle ultrastructure and connective tissues (Armstrong, Warren & Warren, 1991). Talag (1973) stated that due to the high peak force connected with eccentric exercise it can cause greater damage and perceived soreness in the muscles. Clarkson, Byrnes, McCormick, Turcotte and White (1986) further supported that eccentric exercises induce DOMS due to their results indicating that the participants perceived greater muscle soreness after eccentric exercise rather than isometric or concentric exercise. On the other hand it was suggested that the muscle damage was more related to the lengthening of the muscle rather than the peak forces applied (Lieber & Friden, 1991). From these suggestions theories of how DOMS is created and attained can be drawn together.

2.0.2 DOMS Theories
To date there are six theories of DOMS these theories are named lactic acid, muscle spasm, connective tissue damage, muscle damage, cell inflammation and enzyme efflux (Cheung et al., 2003). It is suggested that not one theory alone can explain the reasoning of why athletes attain DOMS (Smith, 1991) therefore for the purposes of this research paper two theories will be looked at more closely than all six; these two theories are inflammation of cells and muscle damage. These two theories have been chosen to be looked at in more detail because they are suggested to correspond with each other (Szymanski, 2001). Another reason is that the two theories can be linked to the two interventions the participants will receive. For example massage is suggested to have physiological effects to return the muscle back to a pre exercise state, and help restore muscle length and tone (Findlay, 2010).

It was first assumed that the by-product lactic acid was the cause for DOMS (Szymanski, 2001); however research has revealed that lactate levels in the muscles reach normal levels 30-60 minutes post exercise (Fitzgerald, Rothstein, Mayhew & Lamb, 1991). DOMS peaks 24-72 hours post eccentric exercise (Powlmans & Smith, 2008); Fitzgerald (1991) stated that the time it takes for an athlete to perceive muscle soreness the lactate levels would have already been restored therefore an association between lactic acid and DOMS is unlikely. This was supported by Armstrong (1984) who stated that eccentric exercise produces less lactate than concentric exercises because it utilizes less oxygen.

Holey and Cook (2006) suggested that during high demands of muscle activity the muscle depletes the metabolic supply and causes a metabolic insufficiency, resulting the muscle releasing an algesic substance. The by-product from the algesic substance can produce pain in the muscle when the metabolic production surpasses the removal of the substance from the blood stream. Hypothesis show that DOMS is related to structural damage to cells in the muscle, such as sarcoplasmic reticulum (Szymanski, 2001). Damage to the sarcoplasmic reticulum causes activation to an enzyme called Calpain which causes further damage to the muscle and the proteins in the muscle (Hilbert, Sforzo & Swensen, 2003). The damage to the muscle protein results in cell inflammation and an increase in muscle temperature, the increase in temperature is due to the cell membrane breakdown and accumulation of chemicals (Szymanski, 2001). As a result of the cell membrane breakdown and the chemicals
involved such as histamines, prostaglandins and potassium the pain receptors are activated (Szymanski, 2001). The physiological effects created through muscle damage leads focus on to the cell inflammation DOMS theory.

2.0.3 Muscle Damage and Cell Inflammation Theories

As previously stated one theory alone cannot explain the reasoning for DOMS, there has been a suggestion to a link between muscle damage and cell inflammation. The inflammatory response has been a suggestion as to being a mechanism of DOMS; the inflammation response is caused by a few factors which is a physiological result from the damaged muscles (Szymanski, 2001). The inflammation is caused by the increase in muscle swelling, prostaglandin and increased macrophages that help repair the tissue which have been damaged. This then increases the intramuscular pressure of the muscle which causes pain and decreases the range of movement; these responses are associated with DOMS therefore linking the sequence of events of the muscle damage theory with the cell inflammation theory (Szymanski, 2001). The swelling which is linked with both the muscle damage theory and cell inflammation theory has been suggested to appear intramuscularly within 24-48 hours and plateau and eventually diminishes post five days (Kraemer, French and Spiering, 2004). This is further supported by Smith (1991) who stated there are similarities between DOMS and acute inflammation as the research of DOMS reflects signs often associated with acute inflammation.

2.0.4 Recovery strategies

Recovery strategies for the effects of DOMS are frequently asked by athletes and therapists, therefore a considerable amount of research has been undertaken by scientists to answer this question. For any injury concerning inflammation the use of nonsteroidal anti-inflammatory drugs (NSAIDs) have been suggested (Donnelly, Maughan & Whiting, 1990), as a result of this scientists proposed the use of NSAIDs on the effects of DOMS (Szymanski, 2001). However this research had conflicting and disappointing results as the effects seem to be minor (Almekinders, 1999). Therefore this leads to question what else can act as a recovery strategy for cell inflammation. Another popular research question to do with cell inflammation is what alleviates the physiological effects of muscle damage which is associated with cell inflammation. Treatment strategies have the aim to restore the muscles back to optimum function as soon as possible, many studies suggest the different recovery
strategies (Cheung et al., 2003) for example different types of massage (Ernst, 1998), stretching (Bobbert, Hollander & Huijing, 1986), cryotherapy (Paddon-Jones & Quigley, 1997), homeopathy (Vickers, Fisher, Smith, Wyllie & Lewith, 1997), ultrasound (Hasson, Mundorf, Barnes, Williams & Fujii, 1990) and electrical current modalities (Denegar, Perrin, Rogol & Rutt, 1989). Each strategy shows different results however most strategies showing no significant results in alleviating DOMS. One suggestion with significant results on DOMS post eccentric exercise is to perform exercise again at a lower intensity (Armstrong, 1984). It was suggested that exercise relieves pain by fibrous adhesions breaking up in the muscle and with the increased blood flow through the muscle the removal of noxious waste is increased (Hough, 1902). To support this Hasson, Williams and Signorile (1989) conducted a study on 10 male participants who performed high velocity concentric and isokinetic exercises 24 hours post an eccentric stepping exercise, results found that 48 hours post concentric and isokinetic exercises there was a significant decrease in DOMS. However Smith (1992) stated that the pain relief from exercise is only temporary and resumes following exercise.

2.0.5 Effects on performance

The effects of DOMS can range from slight tenderness to severe pain depending on the duration and intensity of the eccentric exercises performed by an athlete (Armstrong, Warren & Warren, 1991). It is stated that DOMS is most prevalent at the start of a season or if the athletes are unaccustomed to eccentric exercises which can lead to a decrease in performance (Cheung et al., 2003). As previously stated DOMS can affect a muscle’s function, range of movement, shock attenuation and peak torque. It was also suggested by Cheung et al (2003) an unaccustomed stress on muscle ligaments and tendons due to muscle alterations in sequencing and recruitment. Such effects of DOMS will not allow the athlete to reach their optimum level of performance therefore recovery strategies are of paramount for an elite athlete. This research paper will now look closely at two strategies which require more research into their effects on alleviating DOMS; these two strategies are Effleurage massage and cold water immersion.

2.1 Sports Massage

Massage was first scientifically researched in the 1800s where scientist wanted to explore the effectiveness of massage, from this research new techniques were
developed (Goats, 1994). Since then massage therapy has evolved and there are 8 different types of sports massage, each with their own style of delivery (Tessier, 2005). Massage is used to produce a desired effect on the soft tissues of an athlete which can include the principle of treating a musculoskeletal injury (Cash, 1996). Massage has been suggested to have physiological and psychological effects on an athlete; the psychological effects include preparing the athlete mentally before competition or on the other hand relaxing the athlete so they can focus their attention on upcoming events (Tessier, 2005). Physiological effects include the stimulation of circulation, this increase the amount of oxygenated blood to the area of which is being massage. Other effects include the increase in lymphatic flow, to apply a stretch on the muscle and fascia, reduce pain and relief of muscle spasm (Moraska, 2005). However the eight techniques involved with sports massage can provide different physiological effects from each other. It is commonly used by sports performers and sports therapist due to the enhancement it has on sporting performance (Moraska, 2005).

For the purposes of this study effleurage will be looked at more closely. Effleurage is a Swedish massage technique which involves the use of the massage practitioner’s heel, palm, thumb of the hand and occasionally their fist. With the use of the whole hand a larger surface area is covered during the massage, the practitioner performs effleurage in the direction of the lymphatic flow starting with slow rhythmic stroking and then increasingly becomes faster for more friction to increase skin temperature (Tessier, 2005). An important factor when administrating sports massage is to know if the massage being delivered is a pre event or post event massage to the athlete. This is important as certain types of massage should be avoided, for example pre event massage should not consist of deep tissue techniques (Tessier, 2005).

2.1.1 Post event techniques

A post event massage should ideally be administered within two to six hours post exercise, however the benefits of a post event massage can still be obtained a couple of days after as well (Findlay, 2010). The aim of a post event massage is to increase the healing process of the musculoskeletal structures, massage will relax muscle groups which have become tight due to exercise it can also potentially reduce soreness of muscles (Tessier, 2005). During this type of massage effleurage techniques are applied at a slower rate and slightly deeper; this will enhance the
removal of waste in the muscles and stretch soft tissues (Cash, 1996). Therefore the beneficial physiological effects of a post event massage have been suggested to be associated with the alleviation of DOMS.

2.1.2 Physiological effects

Massage as a technique of recovery has been suggested to be a relevant method for reducing DOMS due to the physiological effects massage produces for the human body (Ernst, 1998). The physiological effects of sports massage can be linked to the potential alleviation of DOMS, for example the increase in lymphatic flow can facilitate the clearance of lactate from the soft tissues (Moraska, 2005). Increased lymphatic flow will also reduce the accumulation of chemical substances which can cause pain in the soft tissues (Ernst, 1998). This can also be linked with the increased stimulation of circulation which reduces oedema (Ernst, 1998). Studies researching the physiological effects of massage on DOMS have varied findings and conclusions.

Smith et al., (1994) conducted a study where eccentric exercises of the elbow flexor and extensors were performed by untrained male participants, two hours post exercise the participants received a 30 minute long sports massage. Results show that perception of DOMS was reduced as well as levels of creatine kinase, other results showed that there was a prolonged elevation of neutrophils and finally cortisol showed a diminished diurnal reduction. Therefore this study concluded that massage will decrease DOMS and serum creatine kinase, a limitation to the study is that the researchers used untrained male participants. This is a limitation as this does not contribute to trained athletes knowledge, as there are physiological comparisons between a trained and untrained athlete (Maron & Pelliccia, 2006). To increase reliability the study should also use trained participants and female participants to see the effects on them. Smith et al., (1994) study suggested that with the increased blood flow the massage creates it disrupts the margination neutrophils; this reduces the production of prostaglandin which as previously stated causes cell inflammation and increase in muscle temperature. This therefore is a positive effect from sports massage as it decreases further damage during the inflammatory process. On the other hand Tiidus and Shoemaker (1995) concluded that effleurage massage delivered to the quadriceps of 9 healthy volunteers created no significant elevation in the arterial and venous blood flow. Therefore the suggestion in which massage
increases blood flow and recovery (Smith et al., 1994) was not present in this study. However a limitation for this study is that only one leg was massaged for the four days in which testing took place, this could have had an effect on the magnitude of blood flow.

Hilbert, Sforzo, and Swensen (2003) conducted a study which measured physiological and psychological effects of massage to DOMS. Findings show that 48 hours post exercise, soreness was significantly lower in the massage group than the control group. However a limitation to this study is the participants varied in gender and age which is not specific to an age group and what the volunteers do is not stated. The findings also show that the physiological effects showed no significant benefit on a participant’s physical performance. However the study did conclude that massage did lower the intensity of soreness when delivered two hours after exercise. The potential mechanism for this is the increased blood and lymphatic flow that massage creates (Moraska, 2005). To support this study Farr, Nottle, Nosaka and Sacco (2002) conducted a study where the participants performed a 40 minute downhill treadmill walk and two hours post this exercise a massage was delivered. The perception of soreness and tenderness was significantly reduced on the leg which received massage; this was compared to the other leg which received no treatment. The potential limitation for the method of only using one leg is that the increased lymphatic flow in the massaged leg will cause a negative effect in the unmassaged leg; this is due to the circulation and is ill-advised by Ernest (1998). On the other hand there was a reduction in isometric strength recorded for the massaged leg; this negative response to massage questions its benefits as a treatment to athletes. In further support of massage Willems, Hale and Wilkinson (2009) findings revealed a reduction in muscle soreness post 48 hours after downhill treadmill walking. This is due to a 25 minute massage, thus concluding that massage is a beneficial recovery method after downhill walking.

Effleurage and Petrissage are the most commonly used massage techniques used with frequent findings of reduced soreness but not significant results in effecting the impaired muscle function, strength and range of movement (Farr et al., 2002; Tiidus & Shoemaker, 1995). However Lau and Nosaka (2011) conducted a cross over study which looked at the effects of vibration treatment on delayed onset muscle
soreness after eccentric exercise; the aim of the study was to see if this treatment reduced DOMS and the effects it places on the muscles. The study compared a 30 minute vibration treatment for four days against no treatment at all. Results showed that there was a significant faster reduction in DOMS for the treatment group two days post treatment and faster recovery range of motion, however the results showed no significant effects on swelling of the muscle or recovery of muscle strength. The results also showed no significant therapeutic effects on the activity of serum creatine kinase. Therefore with this positive result of increasing the range of movement, vibrations and effleurage could complement each other on their effects on DOMS. This is supported by Standley, Miller and Binkley (2010) who stated that combining different massage techniques together can positively improve an athlete’s performance, aid in influencing recovery and effects associated with DOMS for example improving range of movement, blood flow and lactate levels.

2.1.3 Duration of massage

Studies which administered massage two hours post exercise received significant results in the reduction of muscle soreness, these results were recorded 48 hours post exercise (Farr et al., 2002; Hilbert et al., 2003; Willems et al., 2009). Zainuddin, Newton, Sacco and Nosaka (2005) had positive effects for the use of sports massage on the effects of DOMS, 10 participants (5 male and 5 female) performed eccentric exercises of the elbow flexors with one arm receiving a massage three hours post exercise whereas the other arm received no treatment. Results show that the massage decreased 30% of the symptoms associated with DOMS such as pain and soreness, swelling was also reduced. However no significant findings indicated that massage had a recovery effect on muscle strength and function. This study provides valuable information in the duration of when a massage should be delivered and its positive effects on recovery; however more research is needed in to finding recovery strategies for muscle strength and function. Once again this is a study which uses a control limb instead of assessing both limbs; from this the methodology can be a limitation. This is due to the lymphatic flow which can cause a disadvantage for the limb of which was not massaged.

A controversial result of massage on the effects of DOMS compared to other studies as Farr et al., (2002) and Tiidus & Shoemaker, (1995) is the study from Jonhagen, Ackermann, Eriksson, Saartok and Renstrom (2004). 16 participants performed
eccentric exercises of the quadriceps then received a 12 minute massage once a 
day for three days on one leg. Results showed no significant effect on the duration of 
pain and no effect on the loss of strength of function post exercise, therefore 
concluding sports massage will not improve effects of DOMS and should be 
questioned as a recovery strategy. This leads to question the duration of the 
massage. However Best, Hunter, Wilcox and Haq (2008) conducted a review study 
of 27 studies on sports massage for the recovery of skeletal muscle, results showed 
that massage delivered up to two hours post eccentric exercise has been proven to 
produce positive effects on muscular recovery which will benefit all athletes.

The studies reviewed in this paper all have different durations of when the massage 
was delivered post eccentric exercise and the duration of the actual massage. 
Therefore for the purposes of this research the massage variable is 16 minutes long 
with 8 minutes of effleurage on each quadricep; and will be administered straight 
after the eccentric workout without an active cool down. These durations are for 
reliability and validity reasons as the cold water immersion variable required the 
athlete to be submerged for 8 minutes, thus making the variables the same duration.

2.2 Cold Water Immersion

Cold water immersion is the submersion of the body’s limbs or the whole body in 
cold water; depending on what equipment is available this treatment will normally 
take place in a bath. This type of recovery strategy has been taken up by many 
athletes who use this post their event or training; however varied results have been 
shown by studies and has been suggested there is still lack of evidence concerning 
cold water immersion and ice baths (Lateef, 2010). It has been suggested that the 
cold water should be between the temperature of 10-15˚C for physiological effects 
on the muscles (Wittmers & Savage, 2001).

2.2.1 Physiological effects

The main physiological effects associated with cold water immersion are to produce 
an analgesic treatment, reduction of heart rate, cardiac output and oedema, the 
reduction of oedema is due to the vasoconstriction increase and decreased 
peripheral metabolism. As a consequence of this it reduces cellular death from 
muscle damage from exercise (Wilcock, Cronin & Hing, 2006).
Vaile, Halson, Gill and Dawson (2008) conducted a study on hydrotherapy where four variables were tested; they were passive recovery, cold water immersion, hot water immersion and contrast water therapy. The cold water immersion variable was undertaken immediately after DOMS inducing exercises and done again 24, 48 and 72 hours, the variable duration was 14 minutes at 15˚C, the body was fully submerged except for head and neck. Results indicated that 24 and 72 hours post exercise creatine kinase decreased, recovery was improved which lead to a significant increase in dynamic power and there was a significant reduction in swelling when compared to hot water immersion and contrast water therapy. These physiological effects are suggested to be a consequence of hydrostatic pressure the body is placed under during immersion as it creates a displacement of fluids, which creates physiological changes. These include an increase in cardiac output and transport of substrates (Wilcock et al., 2006). The reduction in swelling of the soft tissues lead to Vaile, Gill and Blazevich (2007) to suggest that there is a reduction in oedema, this is due to the re-absorption of interstitial fluid increasing. This then lead Wilcock et al., (2006) to suggest a decrease in secondary damage to the muscles from the cell inflammation response which is created by the eccentric exercises that result as DOMS.

The physiological effects of which cold water immersion provide are an advantage to any athlete for recovery post exercise, however there is question in whether or not this recovery strategy can improve performance. Rowsell, Coutts, Reaburn and Hill (2009) investigated the effect cold water immersion has on physical performance; the study compared cold water and thermoneutral water immersion on junior soccer players. The participants took part in a four day tournament therefore recovery was of paramount. The results indicated that there were no significant effects on performance from the cold water immersion; however the participants perceived general fatigue and lower limb soreness at a lower level which supports cold water immersion as a recovery strategy instead of a performance enhancement.

2.2.2 Duration and Temperature

As with any recovery strategy a frequent question raised is when to administer the treatment and for how long post exercise. Many studies use different methods of duration when using cold water immersion as a strategy for the alleviation of DOMS, methods include the use immediately after exercise, a delay after exercise or 24
hours plus. Ascensao, Leite, Rebelo, Magalhaes and Magalhaes (2010) conducted a study involving 20 male soccer players; they were randomly divided into two interventions, cold water immersion and thermoneutral water immersion which were undertaken immediately after a match. The results reported that cold water immersion significantly decreased perception of muscle soreness, muscle damage and with the possibility of recovering neuromuscular function faster. On the other hand a study conducted by Williams, Landers and Wallman (2011) aimed to compare the effects of immediate cold water immersion and immersion following a three hour delay post exercise. Findings of the study revealed qualitative and quantitative results through the use of a totally quality recovery perception questionnaire. The results favoured immediate cold water immersion for a more efficient performance the following day. Results also indicated the positive effects of cold water immersion following a three hour delay post performance. This would suggest that athletes without immediate access to water immersion facilities post exercise could still experience the physiological benefits.

The temperature of the water is of question to researchers, however many studies have proposed the water to be between 10-15˚C. This is supported by Sramek, Simeckova, Jansky, Savlikova and Vybral (2000) who suggested cold water at the temperature 14˚C provides the most physiological responses, for example there was a 350% increase in metabolic rate compared to water temperature of 32˚C and 20˚C. In support of this White (2011) suggested the temperature of the water should be between 10-15˚C. The duration for the cold water immersion varies with each study, this leads to suggest a need for a justification into what is the most effective duration of a cold water immersion. Wilcock et al., (2006) suggested that for cold water immersion the duration can vary between 15-20 minutes, however it was stated that within the first 10 minutes of immersion changes of the vasomotor happen and then become stable after the 10 minutes (Sramek et al., 2000). Therefore suggesting the immersion does not need to be longer than 10 minutes, other factors involve the participant’s ability to withstand the cold and successfully complete the time requested (Wilcock et al., 2006).

As previously stated muscle damage from eccentric exercise produces cell inflammation and an increased temperature of the muscle (Szymanski, 2001) therefore alleviating these inflammatory responses is important for recovery.
Physiological effects from cold water immersion are suggested to reduce swelling of soft tissue and therefore would be a beneficial strategy on the alleviation of DOMS.
CHAPTER THREE: METHODOLOGY
3.0 Introduction

When conducting any research a number of aspects have to be taken into consideration. Theoretical, practical and ethical issues all need to be addressed and explored. In this section each of the above areas will be discussed with the primary focus of the research being to compare cold water immersion and massage and their effects on DOMS.

3.1 Theoretical Considerations

The prime focus of this investigation is to find out what method of recovery best alleviates the effect of DOMS on university level athletes. The research focuses on finding out outcomes rather than looking at individuals experience’s, therefore placing this research within the quantitative approach. Bryman (2012) further supports this by explaining quantitative research aims to apply their findings to a generalised population whereas qualitative research focuses on contextual understanding of behaviour. Descriptor Differentials Scales (DDS) (Gracely & Kwilosz, 1988) is an appropriate approach for quantitative data collection, therefore this was the method used for this research. The investigation used a crossover study design; this type of design ensures that all participants receive both variables for the same study (Katz, 2006). This study design was chosen due to the advantages that the design provides, such as the participants can act as their own control, the design produces less variability because the participants are not randomised to one variable (Katz, 2006). Katz (2006) also suggested that participants may become more motivated during the study as they are guaranteed to receive both variables. A crossover design can have a disadvantage of which the participants become bias due to carry over effects from the first variable (Katz, 2006). However this study produces a ‘washout’ period (Katz, 2006) of seven days where the participant receives no variable, this should eliminate any carry over effects.

3.1.1 Participants

The participants were chosen from the Cardiff Metropolitan University Women’s Football 1st team focus group, which consists of 15 players. The female players (Mean ± SD; age 20.65 ± 1.06 years, height 167.3 ± 6.58 cm, weight 67.81 ± 6.63 kg) were asked to volunteer due to their standard of play, accessibility to contact, convenience of training times and type of training. The participants were not allowed
to take part in this study if they were currently injured or if they did not have 2 years or more experience training with Olympic weights in a weight gym.

Before the study could begin each participant was required for a short amount of time with the researcher to fill in a client assessment form that provided the researcher with relevant information to see if the participant was suitable for the study. The client assessment form required the participant to know current and previous medical history and relevant medical information that the researcher should be aware of such as allergies (see Appendix A). The participants were provided with an information sheet which explained in detail the objectives of the study and the procedure (see Appendix B) and an informed consent was attained from each participant (see Appendix C). The informed consent clearly explained that the participant can withdraw from the study at any time with no consequences or having to deliver an explanation (Jackson, 2012).

All forms were kept in a safe and secure folder and an electronic copy has been sent to each participant. To comply with the Data Protection Act, the researcher will inform all the participants of where their information obtained from the study will be held and who will have access. For the purpose of this study each of the participants’ information will be held in a folder that only the researcher has access to. This folder will not contain any of the participants’ personal details such as their full name. Before beginning the study the researcher obtained permission from the team coach and the strength and conditioning coach to go ahead with testing.

3.1.2 Instrumentation

Descriptor Differential Scale

Dureja (2004) explains that the DDS is a simple method which is used to assess the sensory intensity and unpleasantness of pain. The DDS allows the participant to rate the magnitude of the pain they are experiencing on a 21 point scale (See Appendix D).

The data was collected through the use of a Descriptor Differential Scale (DDS) (Gracely & Kwilosz, 1988) which was filled out by the participants 48 hours after each variable they experienced. Literature indicates (Polwmans & Smith, 2008) that DOMS reaches its peak between 24 and 72 hours, therefore for the purposes of this study 48 hours post variable was appropriate. The participant’s individual DDS
sheets were coded so that the information collected could stay confidential and anonymous, this was then stored away in a folder for the purposes of the researcher only.

3.1.3 Pilot Study

A pilot study was conducted with the aim to familiarise the researcher with the protocol of the main study. A pilot study is used to identify any possible faults in the procedure such as accessibility to equipment and whether the equipment is working correctly. This pilot study also enabled the researcher to become comfortable with using the equipment and making sure the equipment was ready to use as soon as the participants arrived. Without a pilot study the researcher could put their study at risk as a mistake in the procedure could lead to an effect on the quality and validity of the results (Blessing & Chakrabarti, 2009). There were no changes made after the pilot study was performed.

3.2 Protocol

The participants took part in an hour long strength and conditioning session in a weights gym where eccentric exercises were performed (see Appendix E). Once the session was completed three of the participants immediately received either the cold water immersion variable or the sports massage variable. Prior to the participants finishing their session a risk assessment was conducted and the massage bed was set up and checked thoroughly to eliminate the risk of the bed collapsing. The massage bed was positioned in an appropriate place which would not obstruct any exits in case of a fire or an accident. Also the two ice baths were filled to an appropriate depth with cold water and the temperature was taken with a thermometer.

With the facilities available two participants could receive the cold water immersion variable at the same time in two different baths. Once the baths were filled with cold water to an appropriate depth which would submerge both left and right quadriceps, the participants were asked to remove lower limb clothing except for their underwear. The participants were then asked to carefully get into the bath; once both participants were submerged the 8 minutes would begin.

The participants who received the sports massage variable immediately after the strength and conditioning session were asked by the massage practitioner to lay
supine on the massage bed, standard massage procedure was then administered and permission to touch the participant was granted by the participant. The 8 minute massage on the right quadriceps then began using the techniques in table 1, once completed the same procedure was conducted on the left quadriceps. On the day of the variable before massage was administered the participants were asked if they had any contraindications for example illness, open wounds and acute soft tissue inflammation. If they did the massage was not administered.

48 hours post variable the participants filled in a DDS sheet on their perception of DOMS, the sheets were collected and kept safe in a folder for confidentiality purposes. This was a cross over study therefore seven days after the first variable the participants received the second variable, the same procedure was performed and 48 hours post variable the participants filled in their second DDS sheet.

3.3 Practical Considerations

The primary research method used within this study was the use of a scale (DDS). To ensure data can be collected and gathered successfully it is important that the research method selected is practical. Therefore the following areas were explored to ensure the data could be collected easily: access and availability of subjects, time limitations and the purpose of the investigation.

3.3.1 Access and Availability

This study used 8 participants; the participants would receive a variable one week and the second the next week, to keep experimental errors to a minimum the participants received the variables on the same week day and the same time in the morning. A week gap was between the variables so that the participants were in the same physical state as they were in the first variable. The variables were conducted straight after the participants had partaken in strength and conditioning session, the sessions each week were designed to induce DOMS on the quadriceps through the use of eccentric exercises.

3.3.2 Time Limitation

This study is an undergraduate dissertation which limits the time available for the study and data collection for the researcher. This has had implications on the size of the research. Volunteers of which were injured or sustained an injury during the
duration of the study could not participate, as a result only 8 participants could partake.

3.3.3 Purpose of Investigation

The purpose of this investigation was to provide knowledge and understanding in which recovery strategy, after a bout of eccentric exercises provided a more significant alleviation of DOMS. This study compared cold water immersion and sports massage.

3.4 Detail of Variables

3.4.1 Strength and Conditioning Session

In terms of periodization the participants were in their in-season and therefore the strength and conditioning sessions were based on peaking strength and power, this required eccentric exercises (Fleck & Kraemer, 2004). The sessions provided eccentric exercises for the lower limbs with the use of different equipment found in a weights gym. The participants were accompanied at all times during the session to prevent any risk of injury, the duration of the session was an hour long in which all the participants had completed all sets and reps of each exercise. The eccentric exercises will induce DOMS due to the muscle lengthening while contracting which will create muscle damage (Cash, 1996). This muscle damage can be in the form of fibres tearing and creating a metabolic insufficiency, and the muscle releasing an algesic substance (Holey & Cook, 2003).

An example of the participants training session can be found in Appendix E.

3.4.2 Massage

Before the massage could be administered the participant had to fill in a client assessment form (see Appendix A) so that the researcher could rule out any contraindications the participant may have had. If the participant had a contraindication the massage could not be administered and therefore the participant could not take part in the study (Cash, 1996). The massage was delivered by a qualified sport massage practitioner who used Biotone oil (Natural Living, Herford, United Kingdom) which is suitable for all skin types to decrease risks of a participant having an allergic reaction to the oil. The massage practitioner used the pilot study to familiarize themselves with the four techniques and stroke frequency for the 16 minute massage. Each of the participants lay supine on the massage bed and
received an 8 minute massage on each quadricep using four different effleurage techniques; each stroke was in time with a metronomes beat (Metronome App, Market Wall, 2008) at 78 beats per a minute and each technique was used for two minutes.

**Table 1** The techniques used in the massage variable.

<table>
<thead>
<tr>
<th>Effleurage Techniques</th>
<th>Time</th>
<th>Beats per minute (78bpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat Hand</td>
<td>2 Minutes</td>
<td>Every 2 beats</td>
</tr>
<tr>
<td>‘V’</td>
<td>2 Minutes</td>
<td>Every 2 beats</td>
</tr>
<tr>
<td>Rotary</td>
<td>2 Minutes</td>
<td>Every 2 beats</td>
</tr>
<tr>
<td>Cam and Spindle</td>
<td>2 Minutes</td>
<td>Every 2 beats</td>
</tr>
</tbody>
</table>

These effleurage techniques were chosen due to the recommendation of Cash, (1996) and because of the physiological effects it has on the body (Holey & Cook, 2003). The depth of the massage was not measured however it was kept consistent throughout the testing period. The right quadriceps was massaged first for 8 minutes using the techniques in table 1 and then the left was massaged for 8 minutes.

**3.4.3 Cold Water Immersion**

The cold water immersion variable required the participant to be submerged in a bath full of cold water and a small amount of ice for 8 minutes; this duration was chosen as Sramek et al., (2000) stated that the physiological changes of the vasomotor become stable after 10 minutes of immersion. The participants wore underwear when submerged; no shorts were worn to cover the quadriceps however the participants were allowed to wear clothing on their upper body as this did not interfere with testing. The bath was deep enough to have the participant’s quadriceps fully submerged. A thermometer (Fisherbrand, Factory Calibrated Thermometer, Loughborough, United Kingdom) was used to test the temperature of the water before the participant got in; the temperature of the water in this study began at 12 °C as White (2011) stated that the temperature of the water should stay between 10-15°C. Due to this the water was also tested after 8 minutes when the participant got out of the bath, to measure how much the temperature increased due to the participant’s body temperature. This increased the validity and reliability of the study as the temperature was maintained from all participants. The participants were supervised at all times when in the bath.
3.5 Statistical Analysis

The data was then analysed using the statistical data analysis package which is also known as (SPSS Statistics 20). A dependant t-test was used to see if there was a significant difference between the cold water immersion variable and the massage variable on each individual (Field, 2009).

3.6 Ethical Considerations

Before the investigation commenced it had to be ethically approved by the dissertation board at Cardiff Metropolitan University, once this had been done there was still a number of factors that had to be considered when carrying out this research.

British Educational Research Association (BERA) (2004) explains the importance of participants agreeing to their involvement in the study without any prior pressure being placed on them before the research begins. This research fully supported BERA guidelines and ensured voluntary informed consent was collected from all participants without any pressure. All subjects had the option to take part in the research. BERA (2004) also clarifies that all participants should have the right to withdraw from the research at any point with or without a reason and that they should be notified of this right. The researcher informed participants previously of this right before asking them to take part in any research data collecting and also reminded participants of this right throughout the process of data collection. Due to the nature of the data collection the researcher knew the subjects fairly well however as suggested by BERA (2004) it is important that the privacy of the participants was kept confidential and anonymous. As stated previously this was done by using coded names, which ensured the confidentiality and anonymity of the participants was kept. If all of the above are considered and performed the research should not be jeopardised ethically in any shape of form.
CHAPTER FOUR:
RESULTS
4.0 Results

This chapter demonstrates the statistical results obtained from the main study’s two test variables. The aim of the results was to supply an answer as to which test variable (cold water immersion or massage) would provide better recovery for and alleviate symptoms of DOMS. The study used eight participants (Mean ± SD; age 20.65 ± 1.06 years, height 167.3 ± 6.58 cm, weight 67.81 ± 6.63 kg).

4.1 Data analysis

For every participant their individual scores for each of the 12 verbal descriptors on their DDS sheet was collected as shown in table 3, the mean and standard deviation for each variable was then calculated, cold water immersion (Mean ± SD= 63 ± 21.4) and massage (67.4 ± 18.9). Next SPSS was used to analyse the data, a dependant t-test was used to determine whether or not there was a significant difference in the results from the cold water immersion variable and massage variable. Significance accepted at $p<0.05$.

Table 2 Displays the SPSS dependant t-test outputs of mean ± SD of cold water immersion and massage

<table>
<thead>
<tr>
<th>Test comparing variables:</th>
<th>Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold Water Immersion</td>
<td>63.00 ± 21.44</td>
</tr>
<tr>
<td>Massage</td>
<td>67.37 ± 18.92</td>
</tr>
<tr>
<td>Significant Difference</td>
<td>0.739</td>
</tr>
</tbody>
</table>

Through calculating a dependant t-test table 2 clearly displays the results which show no significant difference ($p>0.05$) between cold water immersion and massage.
Table 3 Displays the scores given for the 12 verbal descriptors from the DDS sheets for each participant

<table>
<thead>
<tr>
<th>Participant</th>
<th>Faint</th>
<th>Moderate</th>
<th>Barely Strong</th>
<th>Intense</th>
<th>Weak</th>
<th>Strong</th>
<th>Very Mild</th>
<th>Extremely Intense</th>
<th>Very Weak</th>
<th>Slightly Intense</th>
<th>Very Intense</th>
<th>Mild</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CWI</td>
<td>Mass</td>
<td>CWI</td>
<td>Mass</td>
<td>CWI</td>
<td>Mass</td>
<td>CWI</td>
<td>Mass</td>
<td>CWI</td>
<td>Mass</td>
<td>CWI</td>
<td>Mass</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>7</td>
<td>1</td>
<td>11</td>
<td>1</td>
<td>9</td>
<td>16</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>6</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>6</td>
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<td>3</td>
<td>6</td>
<td>5</td>
<td>2</td>
<td>13</td>
<td>3</td>
<td>11</td>
<td>13</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>15</td>
<td>1</td>
<td>3</td>
<td>2</td>
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<td>15</td>
<td>1</td>
<td>3</td>
<td>15</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>15</td>
<td>8</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>5</td>
<td>1</td>
<td>17</td>
<td>1</td>
<td>9</td>
<td>15</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>14</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>7</td>
<td>7</td>
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<td>1</td>
<td>3</td>
<td>1</td>
<td>15</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Average</td>
<td>8.25</td>
<td>7.125</td>
<td>1.75</td>
<td>2.25</td>
<td>3.875</td>
<td>6.375</td>
<td>1.125</td>
<td>11.25</td>
<td>12.625</td>
<td>1.25</td>
<td>10.75</td>
<td>3.375</td>
</tr>
</tbody>
</table>
Table 4 Displays the SPSS dependant t-test outputs of mean ± SD for the verbal descriptor ‘Faint’

<table>
<thead>
<tr>
<th>Test comparing variables:</th>
<th>Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold Water Immersion</td>
<td>8.25 ± 6.20</td>
</tr>
<tr>
<td>Massage</td>
<td>7.12 ± 4.01</td>
</tr>
<tr>
<td>Significant Difference</td>
<td>0.68</td>
</tr>
</tbody>
</table>

Through calculating a dependant t-test the results show that there was no significant difference \( (p>0.05) \) between cold water immersion and massage on the verbal descriptor ‘Faint’.

Table 5 Displays the SPSS dependant t-test outputs of mean ± SD for the verbal descriptor ‘Moderate’

<table>
<thead>
<tr>
<th>Test comparing variables:</th>
<th>Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold Water Immersion</td>
<td>1.75 ± 1.03</td>
</tr>
<tr>
<td>Massage</td>
<td>2.25 ± 0.88</td>
</tr>
<tr>
<td>Significant Difference</td>
<td>0.104</td>
</tr>
</tbody>
</table>

Through calculating a dependant t-test the results show that there was no significant difference \( (p>0.05) \) between cold water immersion and massage on the verbal descriptor ‘Moderate’.

Table 6 Displays the SPSS dependant t-test outputs of mean ± SD for the verbal descriptor ‘Barely Strong’

<table>
<thead>
<tr>
<th>Test comparing variables:</th>
<th>Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold Water Immersion</td>
<td>3.87 ± 2.41</td>
</tr>
<tr>
<td>Massage</td>
<td>6.37 ± 3.81</td>
</tr>
<tr>
<td>Significant Difference</td>
<td>0.217</td>
</tr>
</tbody>
</table>
Through calculating a dependant t-test the results show that there was no significant difference \((p>0.05)\) between cold water immersion and massage on the verbal descriptor ‘Barely Strong’.

**Table 7** Displays the SPSS dependant t-test outputs of mean ± SD for the verbal descriptor ‘Weak’

<table>
<thead>
<tr>
<th>Test comparing variables:</th>
<th>Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold Water Immersion</td>
<td>11.25 ± 4.43</td>
</tr>
<tr>
<td>Massage</td>
<td>12.00 ± 5.04</td>
</tr>
</tbody>
</table>

**Significant Difference**

0.786

Through calculating a dependant t-test the results show that there was no significant difference \((p>0.05)\) between cold water immersion and massage on the verbal descriptor ‘Weak’.

**Table 8** Displays the SPSS dependant t-test outputs of mean ± SD for the verbal descriptor ‘Very Mild’

<table>
<thead>
<tr>
<th>Test comparing variables:</th>
<th>Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold Water Immersion</td>
<td>10.75 ± 3.91</td>
</tr>
<tr>
<td>Massage</td>
<td>12.37 ± 4.62</td>
</tr>
</tbody>
</table>

**Significant Difference**

0.590

Through calculating a dependant t-test the results show that there was no significant difference \((p>0.05)\) between cold water immersion and massage on the verbal descriptor ‘Very Mild’.
CHAPTER FIVE:
DISCUSSION
5.0 Discussion

This study compared cold water immersion and sports massage on alleviating the symptoms of DOMS using eight university standard female football players. Looking at the hypotheses in chapter one and the results obtained in chapter four, it appears that the null hypothesis has been accepted in the presentation of no significant difference \((p>0.05)\) between cold water immersion and massage on alleviating DOMS. The findings of this study determine that cold water immersion had no greater or lesser effect on the alleviation of DOMS when compared to sports massage. The research aimed to suggest which out of the two variables was more effective in the alleviation of DOMS. From finding no significant difference between cold water immersion and massage, five individual verbal descriptors were statistically analysed to see if there were significant differences between the two variables. Results show that there were no significant differences \((p>0.05)\) for all five individual descriptors, once again identifying that neither variable had a greater or lesser effect on DOMS when compared to each other. Once more these results which display no significant difference could be due to the amount of participants.

5.1 Sports Massage

The study conducted by Smith et al., (1994) reported a significant \((p<0.05)\) reduction in perception of DOMS after a 30 minute massage. However the study from Smith et al., (1994) used untrained volunteers which is not specific to sport and cannot be related to trained athletes. Trained athletes compared to untrained athletes have physiological adaptations such as cardiovascular, adaptations include increased cardiac output and maximal oxygen uptake (Maron & Pelliccia, 2006) this suggested a faster rate of recovery after exercise compared to untrained athletes. Therefore the study by Smith et al., (1994) may not be used in the support of the present study as untrained athletes perceptions of DOMS may differ from trained athletes. It is highly likely that trained athletes are familiar with the sensations of DOMS, from this familiarity athletes may have their own coping methods with the pain and decreased muscle function. On the other hand untrained athletes may not be familiar with the sensation of DOMS and have no coping technique; therefore there perception of DOMS may be much higher than a trained athlete’s perception. This is also the case for the study conducted by Hilbert et al., (2003) the study used participants that varied in gender, age and whether they were trained or untrained was not stated. On
the other hand this study did find a significant \((p<0.05)\) reduction in the perceived muscles soreness which links with Smith et al., (1994) study.

For an athlete to experience the physiological benefits from massage the massage technique applied needs to increase muscle blood flow, for many studies this has yet to be established (Weerapong, Hume & Kolt, 2005). Tiidus and Shoemaker (1995) concluded that effleurage massage delivered to the quadriceps of 9 healthy volunteers created no significant elevation in the arterial and venous blood flow. However only one leg was massaged, therefore Tiidus and Shoemaker (1995) results cannot be associated with the present study as both left and right quadriceps were massaged. On the other hand the present study did not measure blood flow so could have fallen under the category of not increasing blood flow, this should be considered for future research.

5.2 Cold Water Immersion

As previously stated trained athletes may have different perceptions of DOMS compared to untrained athletes, it is suggested that trained athletes are more resistant to eccentric exercise induced muscle damage and should display a positive response to cyrotherapy (Paddon-Jones & Quigley, 1997). However studies (Gulick et al., 1996) contradict this suggestion as there is a lack of significant findings for both trained athletes and untrained athletes. Cheung et al., (2003) concluded that cold water application provides minimal benefits for the treatment and potential prevention of DOMS. On the other hand a study conducted by Delextrat, Calleja-Gonzalez, Hippocrate and Clarke (2013) suggested that cold water immersion is more useful than sports massage on recovery. This can be linked to the beneficial physiological effects which are present from cold water immersion for example the hydrostatic pressure place on the body or limbs which are submerged (Wilcock et al., 2006). Vaile et al., (2008) concluded that a significant reduction in muscle swelling was the result of hydrostatic pressure and the physiological changes created from this pressure. Other physiological effects from cold water immersion include analgesic treatment, reduction of heart rate, cardiac output and oedema, Wilcock et al., (2006) suggested that from these physiological effects it reduces cellular death; this ties in well with the cell inflammation DOMS theory and how this theory can be treated. However the Delextrat et al., (2013) only found a significant difference in cold water immersion compared to massage on perception of fatigue for the female
basketball participants. A potential reason for this was suggested during a study by Hausswirth and Le Meur, (2011) who stated that after intense exercise women had lower thermolytic capacity than men and should therefore benefit from cold water immersion. On the other hand this present study used trained female footballers and found no significant difference between the two variables. A possible reason for this is that the present study used a DDS whereas the Delextrat et al., (2013) study used a visual analogue scale as their data collection; the two scales would have provided different results on the scales and there is an opportunity for the scales to be interpreted incorrectly.

5.3 Limitations

The group of participants that were chosen for the research were a group of 16 females that formed a focused group of part of the universities women’s football team. This limited the study immensely to sixteen subjects, however this was further hindered as numerous players attained an injury throughout the season. As a result these individuals were unable to take part in the study, resulting in only 8 participants being available. Due to this limited sample size the study was at risk of a type 2 error, a type 2 error is accepting the null hypothesis when in fact it should be rejected (Kothari, 2004). Another limitation was the fact they only had two strength and conditioning sessions a week which limited the time data could be gathered. Therefore the significance of the study may have been affected due to this limited sample size. All of the above factors meant the sample size was small. Quantitative research is meant to be able to be applied to a large scale population (Newman & Benz, 1998) however this may not be the case with this research as the sample size is far too small. Nevertheless it can be used a basis for further research to be carried out in the future.

A key limitation to this study is that there was no control variable, this variable would have identified whether or not DOMS was induced by the eccentric exercises undertaken. This would have also been useful for identifying whether the two recovery variables had an effect on the perception of DOMS.

Although the results showed no significant difference between the two variables it still provides valuable information on how each individual perceived DOMS after each variable. The DDS sheets which were filled out by the athlete show promising results as not one individual rated their DOMS as ‘Extremely Intense’ or ‘Very
Intense’. This information can be valuable to athletes, practitioners and coaches as it shows a positive effect from both the variables as recovery strategies after intense eccentric exercises.

5.4 Strengths

One of the strengths of the study were that it was a crossover study, as previously discussed in chapter three this study design has advantages. The main advantage is that the participants are not randomised to one variable; they experience both variables which produces less variability (Katz, 2006). The study also produced a ‘washout’ period of seven days and therefore eliminated a possible disadvantage of the study design.

The study included the use of only trained athletes from a specific focus group, this focus group were 8 university level female football players. By only using trained athletes from one sport it kept the study sport specific and the information found can contribute knowledge to other trained athletes, coaches and therapists. The research produced in this study may not contribute knowledge to untrained athletes as there are physiological adaptations a trained athlete has attained compared to an untrained athlete (Maron & Pelliccia, 2006).

5.5 Critical review

Not only were time limitations and participant limitations present but the study would have been conducted more efficiently if more facilities were present and if more than one massage practitioner provided the sports massage. With the use of more baths to perform the cold water immersion variable and the use of more massage practitioners the study could have potentially increased the number of participants in this study then time would not have been so much of a limitation.

5.5.1 The Descriptor Differential Scale

The DDS sheets which were used as data collection may not have been the correct choice for this quantitative research study. The scale was previously used on 91 participants who had the lower third molar surgically removed, the scale was taken one and two hours post-surgery (Gracely & Kwilosz, 1988). Another study conducted by Doctor, Slater and Atkinson (1995) used the scale to report pain intensity after electrocutaneous stimulation; the results reported validity in the DDS as a measurement of pain intensity. These studies supported the use of the DDS
however the pain which was imposed on the participants may be more intense than the perception of DOMS which would question the use of the DDS for recording the effects of DOMS. A possible alternative could be the Visual Analog Scale (VAS) this scale requires a participant to rate their level of pain on a 10cm line with one verbal descriptor at either end. For example one descriptor will say ‘no pain’ and at the other end of the line a descriptor will say ‘worst pain imaginable’ (Schofield, Aveyard & Black, 2007). An advantage of the VAS is that when compared to a Verbal Descriptor Scale (VDS) it produces a greater sensitivity (Peters, Patijn & Lame, 2007). However Peters et al (2007) found a disadvantage of the VAS, it was suggested that it may be difficult to understand for some participants as this had the highest number of errors when compared to numerical scales. The main reason suggested for this is that participants may find it easier to understand numerical scales such as the Numerical Rating Scale (NRS). However this scale produced less sensitivity when compared to the VAS. Due to these advantages and disadvantages of pain scales an area for future research could involve finding a valid measuring tool for DOMS.

5.5.2 Participants
Another potential improvement for this study would be to gather a baseline of each participant’s perception of DOMS without the two variables or any intervention; this would then also be compared to the results of the cold water immersion and sports massage variable. This baseline perception will also indicate if the eccentric exercise session induced DOMS on each participant, if the session did not induce DOMS then the study would lose validity and reliability as it would not be testing what it is set out to test.

5.6 Practical Implications
It is worth noting that practical implications that could have effected participant’s perception of DOMS, this would have involved the amount of training performed post variable. Exercise could have had an effect on their perception of DOMS during the 48 hours between receiving the recovery variable and filling in the DDS sheet. Therefore for future research what the participant does during that 48 hours could be controlled to decrease practical implications.

5.7 Future Recommendations
The measures recorded in this study were related to alleviating the physiological effects of DOMS, the soreness levels were recorded using a quantitative approach through the use of a DDS. The DDS also uses psychological principles; this could be useful in collecting more data by the use of questionnaires to get a more in-depth response to a participant's perception of DOMS post variable. This leads to suggest the use of a mixed method design which uses both quantitative and qualitative data in the research. The use of qualitative data collection can also be linked to the psychological effects sports massage can give a participant (Tessier, 2005). The psychological effects that are present with massage and other recovery strategies were not included in this study but for future research psychological effects should be included.

As previously stated there are six theories of DOMS (Cheung et al., 2003), Smith (1991) suggested that not one theory alone can explain the reasoning of DOMS. For the purposes of this study two DOMS theories were focused on and used to explain the reasons of how DOMS is obtained after a session of eccentric exercise. The cell inflammation theory and muscle damage theory were used as it linked with the two variables used in this study. However for future research more than one or two theories should be looked at for a more in-depth look into how the alleviation of DOMS can be maximised and by using which recovery strategy or the use of more than one strategy together. For example a future research study could look in-depth into the six theories of DOMS and perform a longitudinal study on alleviating DOMS using two recovery strategies together. Such as cold water immersion immediately post eccentric exercise then followed by the use of NSAIDs. Another future idea is breaking down the recovery strategy variables, for example the duration of both cold water immersion and sports massage is varied with studies on alleviating DOMS. The duration of a post event sports massage on the alleviation of DOMS could be an area for future research.

This research provides quantitative results of the comparison between cold water immersion and massage on alleviating the effects of DOMS, this research is beneficial for information on recovery strategies. However athletes and coaches also want to know which recovery strategies can optimize an athlete’s next performance, therefore for future research concerning the comparison of cold water immersion and massage a test variable should be introduced 48 hours post recovery variable.
(Cheung et al., 2003). The test variable would be functional test related to football, for example an illinois agility test, 40 metre sprint test or an assessment on the range of movement during a squat. The test variable would take place after each recovery variable and then be analysed and compared using SPSS to see if there were any significant differences, this would then show the effect of each recovery variable on subsequent performance.

Finally the present study only uses effleurage during the massage variable; the physiological responses associated with effleurage favour its effects on alleviating the symptoms of DOMS (Moraska, 2005) however the effects are not in favour on affecting an athlete’s performance. Nosaka (2011) study provided promising results for the use of vibrations as a treatment on performance and Standley et al., (2010) favoured using more than one massage technique together to provide positive results. Therefore for future research the use of more than one massage technique should be considered.
CHAPTER SIX:
CONCLUSION
To conclude the present studies’ results indicated that there was no significant difference between cold water immersion and sports massage on the alleviation of DOMS. A key weakness of this study was the sample size used and baseline measures of each participant’s perceptions of DOMS were not recorded. Therefore whether or not DOMS was induced by the eccentric exercise session was questionable. Future recommended research would include a larger sample size when comparing two recovery strategies and this could be used in a longitudinal study. Another recommended area for future research which would benefit findings associated with DOMS, is for a study to produce a valid measuring tool for DOMS. The results found in the present study do not indicate a negative effect from cold water immersion or massage on the alleviation of DOMS, it only shows that there is no significant difference between them and should not be interpreted in a negative way. The research can be used to advise athletes, coaches and therapist however attention needs to be directed at the small sample size which may have had an effect on results.
CHAPTER SEVEN: REFERENCES
References


CHAPTER EIGHT:
APPENDICES
Appendix A
Client Assessment

Surname: ................................................
Forename: .............................................
Title: Ms/Miss/Mrs/Mr          Gender: Male/ Female          Date Of Birth: ...........................................
Address: ........................................................................
........................................................................

Telephone: .....................................................
Occupation: ...................................................
Name of GP: .................................................................................................
GP Address: ........................................................................
........................................................................

Consultant: ..................................................
Other health care practitioner: .................................................................
Reason for visit?


Contraindications

General Health: How are you feeling today?


Blood pressure:
Reading: .................................. Date: .................. By whom

Medication:
Surgery:

Subject to any medical conditions:

Allergies:

Anything else of relevance that you think I should be aware of?

**Current Medical History**

Is this the first episode of the particular problem?

How, When, What?

Symptoms

What makes condition worse?

What makes it better
Do you experience any ‘Pins and Needles’?

Any loss of power?

**Previous Medical History**

Problem occurred before? How, When, What? Past record?

What was done? By whom?

Results? Investigations? X-rays etc?

**Aims and Objectives**
<table>
<thead>
<tr>
<th>Client Signature</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Massage</td>
<td></td>
</tr>
</tbody>
</table>
Appendix B
**Project Title:** The comparison between Sports Massage and Cold Water Immersion on the alleviation of Delayed Onset Muscle Soreness.

This document provides a run through of:

1) Background and aim of the research  
2) My role as the researcher  
3) Your role as a participant  
4) Benefits of taking part  
5) How data will be collected  
6) How the data/research will be used

The purpose of this document is to assist you in making an informed decision about whether you wish to be included in the project, and to promote transparency in the research process.

**Background and aims of the research**

Recovery for any athlete is extremely important for their next performance and for their health. A factor that decreases performance due to a physical effect it has on an athlete include delayed onset muscle soreness, myself as a researcher would like to investigate ways in which recovery can aid and decrease delayed onset muscle soreness.

**My role as the researcher**

The project involves me (Kimberley Cheffey), the researcher, conducting a study where I require you as the participant to induce the effects of delayed onset muscle soreness onto yourself. This will be done by the use of eccentric muscle contraction exercises; once the exercises are done I will then administer either a sports massage to you or ask you to sit in a cold water bath. You will experience both of these variables but at different dates of the study. I will then give you a questionnaire for you to fill in 48 hours after the variable.

**Your role as a participant**

Your role is to participate in the eccentric muscle contraction exercises on two separate occasions and experience both recovery variables of a sports massage and a cold water immersion. After these two variables you will be required to complete a Descriptor Differential Scale as honestly as you can. The Descriptor Differential Scale will include 12 verbal descriptors about how you are physically feeling and ask
you to rate each descriptor as your answer; therefore you will not need to write any answers just provide a tick on the scale.

**Benefits of taking part**

The information I obtain from this study will allow better insight into whether or not there are effects of massage or cold water immersion on delayed onset muscle soreness during recovery. From this I aim to understand how each participant feels after each variable relating to their delayed onset muscle soreness, and compare their Descriptor Differential Scale scores from the massage variable to the cold water immersion variable. I will be happy to share this information to any of the participants of this study. On request, I can also provide you with your own personal results, and discuss this with you.

**How data will be collected**

As mentioned above, data will be collected solely from the Descriptor Differential Scale I will provide you.

**How the data/research will be used**

In agreeing to become a voluntary participant, you will be allowing me to use your responses to the Descriptor Differential Scale and include them within a larger data set that includes the data of other participants. Your personal data will be anonymous and will not be reported alone, but within the total sample of participants.

**Your rights**

Your right as a voluntary participant is that you are free to enter or withdraw from the study at any time. This simply means that you are in full control of the part you play in informing the research, and what anonymous information is used in its final reporting.

**Protection to privacy**

Concerted efforts will be made to hide your identity in any written transcripts, notes, and associated documentation that inform the research and its findings. Furthermore, any personal information about you will remain confidential according to the guidelines of the Data Protection Act (1998).

**Contact**

If you require any further details, or have any outstanding queries, feel free to contact me on the details printed below.

Kimberley Cheffey
Cardiff School of Sport
Cardiff Metropolitan University
CF236XD, United Kingdom
Email: st10001830@outlook.uwic.ac.uk
Appendix C
CARDIFF METROPOLITAN
INFORMED CONSENT FORM

CSS Reference No:

Title of Project: Effects of Sports Massage and Cold Water Immersion on Recovery

Name of Researcher: Kimberley Cheffey

Participant to complete this section: Please initial each box.

1. I confirm that I have read and understand the information sheet dated .......... for this evaluation 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 this happens, our relationships with the Cardiff Metropolitan University, or our legal rights will not be affected.

4. I understand that information from the study may be used for reporting purposes, but I will not be identified.

5. I agree to take part in this study.

Name of Participant

________________________________________________________________________________

Signature of Participant                              Date

________________________________________________________________________________

Name of person taking consent                       Date

________________________________________________________________________________

Signature of person taking consent                  Date

* When completed, one copy for participant and one copy for researcher’s files.
Appendix D
Descriptor Differential Scale

EACH WORD REPRESENTS AN AMOUNT OF SENSATION.
RATE YOUR SENSATION IN RELATION TO EACH WORD WITH A CHECK MARK.

- Faint
- Moderate
- Barely Strong
- Intense
- Weak
- Strong
- Very Mild
- Extremely Intense
- Very Weak
- Slightly Intense
- Very Intense
- Mild
Appendix E
Table 9 Displays a typical eccentric exercise session

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Sets</th>
<th>Reps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Squats</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Reactive Jumps</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Superset</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bench Press</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Medball Chest Throw</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Superset</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supine Row</td>
<td>3</td>
<td>Max</td>
</tr>
<tr>
<td>Medball Slams</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>No Superset</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hang Clean</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>No Superset</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lateral Steps (with band)</td>
<td>3</td>
<td>5 left 5 right</td>
</tr>
</tbody>
</table>