Cardiff School of Sport

DISSERTATION ASSESSMENT PROFORMA:

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Comments	Section
	Title and Abstract Title to include: A concise indication of the research question/problem. Abstract to include: A concise summary of the empirical study undertaken.
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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

The comparison of Sports Massage and Self-Myofascial Release on hamstring flexibility of male athletes

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THE COMPARIOSN OF SPORTS MASSAGE AND SELF-MYOFASCIAL RELEASE ON HAMSTRING FLEXIBILITY OF MALE ATHLETES

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Acknowledgements

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Abstract

Flexibility is one of the critical key factors that contribute to successful athletic performance and the use of sports massage and self myofascial release (foam rollers) as modalities for improving flexibility and thus aiding physical performance has been well established and practiced within sport. Despite this, scientific evidence on the effectiveness of these treatments is controversial and literature on the comparison of their effects on flexibility has not been reported.

The aim of this study was to compare the effects of sports massage and self-myofascial release on hamstring flexibility of male athletes.

Eight (n = 8) physically active, male team players studying sport at Cardiff Metropolitan University, with a finger-ground distance greater than 0cm, volunteered to participate within this study. Participants were randomly assigned into two groups of 4, where each group engaged in one of two interventions for a period of three days, a sports massage and a foam rolling intervention. After a washout period of 7 days, the groups engaged in the alternative intervention. Prior to and following each intervention period, measures of hamstring flexibility were obtained using the sit and reach test, back saver sit and reach test and the active knee extension test. The sports massage intervention involved a 20 minute controlled, manual massage to the hamstrings and the foam rolling intervention comprised of 20 minutes of controlled, self-delivered, hamstring foam rolling. A one way repeated measures ANOVA was used to identify significant differences between pre and post hamstring flexibility measurements whilst a paired samples t-test was conducted to reveal any differences between the effects of the interventions.

Analysis of the main study data demonstrated that the sports massage intervention had no significant effect on hamstring flexibility ($p > 0.05$) whereas the foam rolling intervention had a significant effect on the performance in the active knee extension test ($p < 0.05$). No significant differences were found between the effects of sports massage and foam rolling on hamstring flexibility.

The present findings indicate that a 20 minute hamstring sports massage is an ineffective modality for increasing hamstring flexibility, whereas a 20 minute application of foam rolling to the hamstring muscle group is effective in improving hamstring flexibility measured through the active knee extension test. Further research is required to validate the physiological benefits of sports massage, support the findings in relation to foam rolling and evaluate differences between the two modalities.

CHAPTER ONE
INTRODUCTION

1.0 **Introduction**

Recent results and evidence support a growing literature suggesting that engagement within physical activity has beneficial outcomes, both physically and mentally (Penedo and Dahn, 2005). Therefore, assessment and promotion of regular exercise and physical activity is significant in achieving and maintaining the desired benefits associated with good health and a better quality of life.

With increasing participation in sports and other recreational activities, injury rates have increased. For this reason prevention of injury has become recognised as a necessity (Halbertsma, van Bolhuis and Goeken (1996) and Thacker, Gilchrist, Stroup and Kimsey, (2004)). It has been identified that within team sports such as football and rugby, injuries commonly occur to the lower extremities (Junge, Cheung, Edwards and Dvorak, 2004). Hamstring injuries have been recorded as having the highest incidence rate within team sports which require maximum sprinting, acceleration, kicking and rapid change of direction (Brughelli & Cronin, 2008), with male athletes 62% more likely to sustain these injuries than females (Cross, Gurka, Conaway and Ingersoll 2010). In addition to high incident rates, hamstring injuries also exhibit significant sporting absence and high susceptibility of re-injury. A cohort study analysing hamstring muscle injuries in professional rugby union recorded that 24% of match and 20% of training injuries were recurrences with the mean severity greater than that of new injuries (Brooks, Fuller, Kemp and Reddin, 2006).

Some studies support the notion that decreased hamstring flexibility is a risk factor for hamstring strain injuries and can also cause symptoms of muscle damage following eccentric exercise (Hopper, et al, 2005). Yet there is conflicting literature on the relationship between flexibility and muscular injuries. It is unclear that an optimal level of flexibility exists, however it is imperative to appreciate that the degree of flexibility is specific to areas of the body, exclusive to demands of a sport and that all movements require different ranges of motion (Alter, (2004) and Knudson et al, (2000)).

It is generally accepted and widely known in athletic performance of both recreational and competitive natures that the inclusion of stretching activities, prior to or following engagement in exercise, benefits an individual by not only enhancing physical performance but is also closely linked to preventing sports-related injuries (Shellock and Prentice, 1985). Stretching of the working muscles, through prescribed programmes, is therefore a generic focus in the daily routines of many athletes.

Stretching has been defined as “movement applied by an external and/or internal force in order to increase muscle flexibility and/or joint range of motion” (Weerapong, Hume and Kolt, 2004, p190). Primary hamstring flexibility enhancement modalities reported are static, dynamic, ballistic and PNF (Decoster, Cleland, Altieri and Russell, 2005) .There is however a lack of agreement as to the most effective technique (George et al, 2006). Other treatment modalities including sports massage and self-myofascial release have not been systematically examined.

Sports massage as a treatment modality is common practice within the field of sport. Specific sports massage techniques involve deep longitudinal stroking of specific localised areas of tissue that result in a stretching effect (Cash, 1996), improving range of motion as a consequence. Several studies have reported an increase in hamstring flexibility through the application of sports massage (Crosman, Chateauvert and Weisberg, 1984 and Vennard, 2005), yet other studies present contradicting results (Wiktorsson-Moller, Oberg, Ekstrand and Gillquist, 1983).

Furthermore, self-myofascial release through the application of foam rollers is becoming a widespread stretching treatment modality believed to treat individuals with a variety of soft tissue conditions including muscle tightness (Miller and Rockey, 2006) despite the significant lack of scientific evidence. MacDonald et al (2012) and Mohr (2008) documented an increase in joint range of motion through the use of foam rollers however conversely Miller et al (2006) reported foam rolling to be an ineffective technique for increasing hamstring flexibility.

Both sports massage and self-myofascial release have been identified to have similar biomechanical mechanisms to common stretching techniques. Therefore this poses the question as to why the effects of these techniques on flexibility and athletic performance have not been investigated further.

1.1 Aims and Objectives

The aim of this study was to compare the effects of sports massage and self-myofascial release on hamstring flexibility of male athletes. The outcome will conclude which treatment modality, sports massage or self-myofascial release, is more effective in improving flexibility in athletes.

1.2 *Study Rationale*

Despite the fact that both sports massage and self-myofascial release are readily available within sport to serve athletic performance, there is a distinct gap within the literature as to the comparison of their effects on flexibility. Over the last three years, the author has undertaken work within the discipline of sports massage with individuals from a variety of sports in a number of different environments. Hence, persistence to fulfil a study based on sports massage derives from a positive practical perspective. Through personal experience, the author acknowledges that both sports massage and self-myofascial release can be used for increasing flexibility, however evaluation of the most effective treatment has not been determined. The need for scientific evidence to support and investigate these findings is therefore required. Knowledge and understanding of this information will allow for appropriate practical application within sport in order to specifically meet required physiological demands of an individual. Furthermore, by identifying a relationship it would help contribute to current literature regarding the effects of sports massage and foam rolling on athletic performance and human functioning.

1.3 *Main Study Research Hypothesis*

The following hypotheses are based on aforementioned literature and derived from the research questions.

Null hypothesis

H0 – It is hypothesised that following a three day sports massage and foam rolling intervention there will be no statistically significant improvement in hamstring flexibility and no statistically significant difference in effects of each intervention.

Research question 1

1. Does the application of sports massage improve flexibility of the hamstring muscle group?

H1 – It is hypothesised that following a three day sports massage intervention, there will be a statistically significant improvement in hamstring flexibility.

Research question 2

2. Does the application of foam rolling improve flexibility of the hamstring muscle group?

H2 - It is hypothesised that following a three day foam rolling intervention, there will be a statistically significant improvement in hamstring flexibility.

Research question 3

3. Is the application of sports massage more effective than the application of foam rolling in improving flexibility of the hamstring muscle group?

H3 – It is hypothesised that following a three day sports massage intervention, there will be a statistically significant improvement in hamstring flexibility compared to a three day foam rolling intervention.

Research question 4

4. Is the application of foam rolling more effective than the application of sports massage in improving flexibility of the hamstring muscle group?

H4 – It is hypothesised that following a three day sports massage intervention, there will be a statistically significant improvement in hamstring flexibility compared to a three day foam rolling intervention.

CHAPTER TWO
REVIEW OF LITERATURE

2.0 **Review of Literature**

2.1 Flexibility

2.1.1 Definition of Flexibility

Flexibility is a well-recognised, fundamental fitness component that enables efficient human movement and performance which in turn is used to achieve positive health benefits (Knudson, Magnusson and McHugh, 2000). However, the term flexibility is theoretically unclear, inconsistent in terminology and overall poorly understood. Various authors have addressed the definition of flexibility similarly, describing the range of motion of a joint (Bandy, Irion and Briggler, (1998), Blum and Beaudoin, (2000) and Barlow, Clarke, Johnson, Seabourne, Thomas and Gal, (2004)). Yet, Robinson (2004) identifies this is incorrect and ill-defined due to the inconsideration of the surrounding tissues of a joint. Acknowledging this limitation, Holt, Holt and Pelham (1996, p.72) re-defined flexibility as:

> *"the intrinsic property of body tissues which determines the range of motion achievable without injury at a joint or group of joints".*

In agreement, authors Thacker et al (2004) and Anderson, Pearl, Burke and Galloway (2007) state that the range of motion at a joint is influenced by muscles, tendons, ligaments, bones and bony structures.

2.1.2 Static and Dynamic Flexibility

Flexibility has a static and dynamic component. Static flexibility can be described as "linear or angular measurements of the actual limits of motion in a joint or joint complex (Knudson, 2007, p.78), whereas dynamic flexibility refers to range of motion during active movements (Baechle and Earle, 2008).

Although several resources have established normative data for static and dynamic flexibility of the major joints, current research does not identify an optimal level of flexibility (Knudson et al, (2000) and Chandler and Brown, (2008)). Appropriate flexibility allows muscular tissues to accommodate imposed stresses and promote efficient movement thus decreasing risk of injury and enhancing performance (Ferreira, Teixeira-Salmela and Guimaraes, 2007).

2.1.3 Hamstring Flexibility

Relative inflexibility has been suggested to be a predisposing intrinsic factor of muscular injury (Standert and Herring, 2003). Some studies have reported a relationship between flexibility and hamstring injury (Hartig and Henderson, (1999), Witvrouw, Danneels, Asselman, D'Have and Cambier, (2003) and Bradley and Portas, (2007)). However, this relationship is complex and supportive evidence is lacking. Yet, it has been documented that an individual who significantly deviates from the norm of static hamstring flexibility towards pathologically low or excessive joint range of motion, defined as ankylosis and hypermobility respectively (Knudson et al, 2000), are at higher risk of musculoskeletal injuries (Jones et al, (1993) and Jones and Knapik, (1999)). Furthermore, in relation to specific injuries, it has been suggested by Taimela, Kujala and Osterman (1990) that athletes with low flexibility, tight muscles, are more susceptible to muscle strains, whereas athletes with greater flexibility, ligamentous laxity, are subject to a higher risk of sprains. Conversely, some literature presents an inverse relationship between flexibility extremes and performance suggesting that less flexible joints are beneficial and economical to an athlete's running performance (Gleim, Stachenfeld and Nicholas, 1990 and Craib et al, 1996). It therefore appears that what is desirable based on current evidence is to avoid both extremes of static flexibility in order to reduce injury rates.

2.1.4 *Hamstring Flexibility Testing*

Physical fitness testing is a routine component for many athletes. Flexibility testing procedures are acknowledged to be beneficial for many purposes including identification of performance-limiting factors and assessment of intrinsic risk factors of sport injury (Bozic et al, 2010). Hamstring flexibility can be assessed in several ways. The most common method documented in the literature is the sit and reach test (SR) (Jones, Rikli, Max and Noffal, (1998), Knudson et al, (2000), Baltaci et al, (2003)). Even though the SR has been found to be valid and reliable for measuring hamstring flexibility (Baltaci et al, 2003) the main reason for frequent use is its simplicity, easy administration and minimal skill training requirements (Planteleimon, Panagiotis and Fotis, 2010). The back saver sit and reach test (BSSR) is a modification of the traditional SR where one hamstring is tested at a time as opposed to both hamstrings. The rationale for the BSSR derives from Cailliet (1998) who suggested that stretching one hamstring at a time will result in less stress and risk of injury for the lower back and spine. Baltaci et al (2003) also found the BSSR to be an accurate alternative measurement of hamstring flexibility. Additionally, the active knee extension test (AKE), also referred to as the 90/90 test (Howley and Thompson, 2012) was developed to offset limitations found with other tests. Gajdosik and Lusin (1983) found the AKE to be a consistent and objective tool with a high reliability coefficient of r=0.99. Another study supported these findings, and concluded that the AKE was high in reliability (Norris and Matthews, 2005).

2.2 *Stretching Modalities*

It is common practice to include stretching within sport and athletic training programmes. The reasons for this relate to beliefs that stretching exercises will increase flexibility and decrease muscle stiffness, thus preventing muscular injuries (Halbertsma et al, 1996) and improving performance. Stretching is the “systematic elongation of musculotendinous units to create a persistent length of the muscle and a decrease in passive tension” (American College of Sports Medicine (ACSM), 2006, p.159) with the objective being to improve flexibility.

2.2.1 *Types of Stretching Techniques*

There are various stretching techniques used, often depending on the athlete and the sport. Three common variations of stretching technique exist - static, dynamic and proprioceptive neuromuscular facilitation (PNF) (Woods, Bishop and Jones, 2007). These methods of stretching are frequently investigated particularly in relation to joint range of motion, however comparative studies indicate that PNF is superior in increasing flexibility (Shrier and Gossal, (2000) and Funk et al, (2003)).

There is a wealth of research that considers stretching to increase hamstring flexibility. A systematic review to investigate the most effective positions, techniques, and durations of stretching to improve hamstring muscle flexibility was conducted by Decoster, Cleland, Altieri and Russell (2005). Improvements in range of motion after stretching were found in 28 articles, with a cumulative number of 1338 subjects. The studies however focused solely on stretching alone and no other treatment modalities were analysed. Yet, there is a lack of agreement as to the most effective way to lengthen the hamstring group (George et al, 2006).

The effects of stretching have been extensively researched. However there is little evidence comparing other modalities that have similar biomechanical mechanisms of stretching.

2.3 *Sports Massage*

Sports massage is a deep form of soft tissue work applied specifically within a sporting context with the general focus to maintain the health and wellbeing of an athlete and enhance physical performance (Findlay, 2010 and Benjamin and Lamp, 2005). The development and utilisation of sports massage has led to a growing interest within sport and it now maintains a high profile as an integral part of an athlete's conditioning. Massage in sport has been promoted as a form of treatment for both physiological and psychological aspects related to sports participation (Findlay, 2010). Preparing for exercise as well as recovering from exercise and facilitating the rehabilitation of sporting musculoskeletal injuries

(Brummitt, 2008) are a few examples of the applications of sports massage. Specific sports massage techniques are recognised as methods of stretching due to their mechanical function of softening and elongating the soft tissue structures within a muscle (Findlay 2010).

2.3.1 Sports Massage Techniques

Massage involves mechanical manipulation of body tissues with rhythmical pressure and stroking (Weerapong, Hume and Kolt, 2005), through integration of a collection of different techniques to accomplish a desired effect in the soft tissues. Five basic techniques are commonly reported in the sports massage literature. These are effleurage, petrissage, vibration, tapotement and friction (Callaghan, (1993), Vennard, (2005), Moraska, (2005) and Standley, Miller and Binkley, (2010)).

The combination of effleurage, petrissage and vibration techniques can positively influence treatments in improving range of motion (Standley et al, 2010). The application of these techniques is believed to stimulate the stretching effect. The deep longitudinal stroking stretches the localised areas of tissue by drawing them apart (Cash, 1996). It is therefore hypothesised, that the mechanical effect of these techniques can increase flexibility.

2.3.2 *Sports Massage and Flexibility*

Several studies have examined the effect of massage on joint range of motion however the experimental results are equivocal.

The first ever research study to use sports massage as a stretching modality was conducted by Wiktorsson-Moller, Oberg, Ekstrand and Gillquist (1983). It examined the effects of massage on lower extremity ROM compared to other pre-exercise activities of warming up and stretching. The results found that massage only made a significant difference to ankle dorsiflexion whereas stretching significantly increased all lower extremity ROM measurements. Wiktorsson-Moller et al (1983) therefore claim that stretching is superior and the most effective way to increase flexibility. Yet the age of the study could be seen in itself as an unreliable source.

Additionally, two studies that both investigated the effect of a 15 minute, single hamstring massage on the performance of the sit and reach test using 11 active, young men (Barlow et al, 2004) and 10 male adolescent soccer players (Jourkesh, 2007) indicated no changes in ROM and therefore no significant increases in the performance of the sit and reach test was recorded. However due to the design limitations of these studies using small sample sizes, the validity of the results is compromised.

In contrast, Crosman, Chateauvert and Weisberg (1984) designed a study to measure the effect of a 9-12 minute, single massage treatment to the hamstring muscle group on ROM using 34 normal female subjects. The results of the study determined that there was a statistically significant ($P>0.05$) increase in ROM immediately post massage and was evident for at least seven days, while the long term effects of massage was considered insignificant. Even so, it was concluded that “massage to the hamstring muscle group is an effective means of increasing range of motion and should be an integral part of patient care” (Crosman et al, 1984, 171).

Furthermore, another study by Vennard (2005) reinforces the results documented by Crosman et al (1984). This study used both male and female college students to examine the effects of two massage sessions per week for three weeks on hamstring flexibility. The results obtained showed a significant increase in hamstring flexibility for the massaged leg from the initial to the final session. These sessions were separated by 23 days and paired t-tests were used to analyse the long term effects of massage by comparing initial and final hamstring flexibility measurements. Therefore the results contradict the findings of Crosman et al (1984) on the long term effects of massage on hamstring flexibility.

Scientific studies and evidence to support the effects of sports massage on flexibility are very few, therefore weakening the previous statement made by

Crosman et al (1984). The authors Galloway and Watt (2004) argue that the lack of scientific findings in the existing literature on the efficiency of massage makes it difficult to justify its use at major athletics events. Despite this, their study found that between 1987 and 1998 twelve major athletic events from national to international level employed massage as a form of therapy accounting for approximately 45% of total treatment time at athletic events.

2.3.3 *Sports Massage Length*

Findlay (2010) outlines that the duration of a sports massage can range from five minutes to an hour and a half, but no longer, as the body can get overloaded, potentially defeating the purpose. Due to the wide margin, current research study designs differ hugely with regards to the time of massage application. For example, within a study implemented by Huang et al (2010) short duration massages of 10 and 30 seconds were applied to the hamstrings musculotendinous junction. The most important result was the significant increases in hip flexion range of motion with only 10 seconds (5.9%) and 30 seconds (7.2%) of musculotendinous massage. Huang et al (2010) discusses that such short duration massages can be beneficial within the time limitations of most warm-ups and cool downs. Conversely, Watt (1999) disputes this stating that a leg massage should last approximately 10 minutes, with most massage requiring 10-30 minutes. However, in two studies previously mentioned by Barlow et al (2004) and Jourkesh (2007), a 15 minute massage to the hamstring muscle group was ineffective. After further analysis of these studies no descriptive information was found on the massage procedure. Without this, the appropriateness of the intervention cannot be evaluated, and more importantly cannot be reproduced (Robertson, et al 2004). Furthermore, another study to find massage an insignificant method for improving range of motion (Wiktorsson-Moller et al, 1983), varied the length of massage between 6 and 15 minutes depending on how tense the masseur felt the muscles to be. This decreases the reliability of this study as muscle tension would have been different for each participant therefore each massage would have been of varying lengths.

Robertson et al (2004) make the point that physiotherapists who are largely responsible for massage delivery at major athletics events, tend to deliver massage treatment for 20 to 30 minutes. Yet, Callaghan (1993) argues that the length of time is based solely on the athlete's preference and not on scientific data.

2.3.4 *Comparison of Massage to other Stretching Modalities*

In current literature, many research experiments focusing on the subject of massage have used similar control conditions in their method designs. To analyse the proposed hypotheses of these experiments, numerous studies have used two groups of participants, an experimental group and a control group, a massage intervention as opposed to no massage or a passive rest intervention respectively (Crosman et al, (1984), Hemmings, Smith, Graydon and Dyson, (2000), Barlow et al, (2004), Robertson, Watt and Galloway, (2004), Vennard, (2005) and Hunter, Watt, Watt and Galloway, (2006)). Additionally, other studies have examined different types of massage against each other (Hopper et al, (2005), Hopper, Conneely, Chromiak, Canini, Berggren and Briffa,(2005) and Cherkin, et al, (2011)), yet research on the comparison of massage to other stretching modalities is lacking. One of the very few that exist, a study by Witorsson- Moller et al (1983) assessed three common strategies of warming up, massage and stretching. The effects of massage were compared to the effects of general warming up, general warming up and massage together and general warming up and stretching together. Yet, a direct comparison could not be made because stretching was not tested alone. Another study investigated the effects of different thermotherapies on hamstring flexibility (Cavalieri, 2001). In this case the effect of massage plus dynamic stretching was compared with hot pack therapy plus dynamic stretching and dynamic stretching alone. However, the timing variable was not consistent because only 12 minutes was given to massage against 20 minutes given to the hot pack therapy and the period of no treatment. In addition, the effects of massage alone were not tested because it was combined with dynamic stretching.

Due to these inconsistencies and lack of standardisation it is necessary to compare massage alone against other techniques using consistent variables. Only then can a true comparison be made of the effects of these techniques.

2.4 *Myofascial Release*

Myofascial release is a soft tissue massage technique that involves practical manipulation of the connective tissues or fascia in the body (Palmer & Reid, 2009). Fascia surrounds every muscle of the body serving major purposes as a structure, ultimately determining the length and function of its muscular component. If however the body or part of the body is exposed to any type of trauma or injury, the fascial system will malfunction. Barnes (2009) explains that fascia strains, as a result of damage, can slowly tighten causing loss of flexibility and spontaneity of movement thus placing the body at risk of more trauma, pain, and limitation of movement. Due to the whole-body, hands–on approach, it is argued by Barnes (2009) that myofascial release is one of the most potent and effective ways of locating fascial restrictions and achieving positive change. It has been proposed that myofascial release improves soft tissue extensibility. Through a review of myofascial release as an effective massage therapy technique by Paolini (2009) seven of the reviewed articles supported this statement. Myofascial release techniques however require a skilled clinician and can be costly and time consuming (Mohr, 2008), therefore a technique known as self-myofascial release is a beneficial alternative.

2.4.1 *Self-Myofascial Release*

Self–Myofascial Release (SMR) is becoming an increasingly popular stretching technique amongst the sporting population. The principles and effects of SMR are similar to myofascial release however the techniques are administered by the subject themselves and involve the use of body weight to exert pressure and tension to a group of muscles (Mohr, 2008). The application of this technique can use a variety of tools to provide reasonably comfortable massage to the tight muscles, including foam rollers, medicine balls, tennis balls and myofascial sticks, with foam rolling being the most versatile.

2.4.2 *Foam Rolling*

Foam rolling is a common self-myofascial release stretching technique that uses a cylindrical tube of various circumferences, lengths and densities (Mohr, 2008 & Emmons, 2010). The rationale for the use of foam rollers dates back to the late 1950s where Dr. Moshé FeldenKrais was credited as the first person to use rollers for therapeutic purposes (Knopf 2011). Recent claims suggest foam rollers can increase soft tissue extensibility and improve flexibility thus increasing range of motion (Robertson, 2008, Clarke, Lucett and Kirkendall, 2009, Emmons, 2010, Knopf 2011). However this field of study is controversial. There are only a small number of studies that have researched the effects of foam rollers and the conclusions are inconsistent.

Firstly, Mohr (2008) conducted a study with the purpose of examining the effects of foam rolling compared to a regular static stretching protocol on hamstring flexibility. The methodology involved four experimental groups – static stretching, foam rolling and static stretching, foam rolling and control, with hip flexion as the dependant variable that was measured. The findings showed that foam rolling alone did increase hip range of motion more than the control, however when combined with static stretching demonstrated the greatest gains. Therefore, clinically this study established that foam rolling to the hamstrings prior to static stretching would be an appropriate and effective way to increase hip flexibility in non-injured patients who have less than 90° of hamstring ROM (Mohr, 2008).

Similarly, D’Amico and Morin (2011) also assessed the effects of self-myofascial releasing on flexibility compared to static stretching and control. It was concluded from this study that hamstring range of motion was greater in both treatments of self-myofascial release using a foam roller and static stretching compared to the control group. However, it was also noted that there was no significant difference between each treatment. Static stretching is usually recommended for most individuals as a safe, simplistic and time efficient method to improve range of motion (Mackinnon, Ritchie, Hooper and Abernethy, 2003). These findings may be of interest to professionals in sport, as self-myofascial release through the use of foam rollers could be used in addition to or as a replacement for static stretching.

D'Amico and Morin (2011) state that given the results of their study, self-myofascial release should be considered as a valuable tool for preparing an athlete for exercise.

Recent research by MacDonald et al (2012) strengthens the results found on the effects of foam rolling on range of motion. The authors designed a study to determine the effects of self-myofascial release via the application of foam rolling on knee extensor force and activation, and knee joint range. The method consisted of a foam rolling condition and a rest condition where the subjects foam rolled on their right quadriceps for 2, 1 minute bouts with 1 minute rest between bouts. Within the experimental condition all dependent variables were measured: 2 minutes pre-condition then 2 and 10 minutes post condition. It was found that the subjects range of motion significantly increased by 10 and 8% at 2 and 10 minutes respectively. More importantly, from the results it was strongly concluded that acute foam rolling had no significant impact on quadriceps muscle force or activation. These results can be of great significance practically as a technique that can enhance range of motion without inhibiting muscle performance and could be of value in treating joint mobility injuries (MacDonald et al, 2012). Based on this study, there is a need for future research to determine the effects of longer durations of foam rolling on range of motion.

Conversely, an investigation performed by Miller and Rockey (2006), challenges the outcomes of the previous work. The objective of their study was to discover if foam rolling over an eight week period would increase flexibility of the hamstring muscle group. The results revealed there was no significant differences between the treatment and control group, however it was reported that both groups had a significant increase in range of motion. Although, increase in flexibility was reported for the treatment group, the values were insignificant when analysed with the control as an increase in flexibility was also noted for this group. Hence it was concluded that foam rollers were ineffective for increasing flexibility of the hamstring muscle group. Additionally, a limitation of this study is that even though Miller and Rockey (2006) stated that the experimental measurements were to be taken midway through the protocol period at 4 weeks, results of these were not presented and evaluated within their results. Furthermore, this study did not compare foam rollers to any other stretching protocol.

Although, sports massage and foam rolling as techniques for stretching have both been compared and examined to other forms of stretching there are very few, if any, studies that have compared them to each other.

CHAPTER THREE
METHODOLOGY

3.0 **Methodology**

3.1 *Familiarisation Trials*

Prior to the study period, participants undertook familiarisation trials to practice on equipment and understand what was expected of them, for example testing duration and intensity (Dunford and Doyle, 2008). Explanations and demonstrations were given of the warm up and how to perform each test. The participants did not perform the warm up however they did practice each test, with the equipment until they felt comfortable and demonstrated the correct technique (Gore, 2000). Additionally, the sports massage therapist completed a familiarisation treatment on an individual of similar qualities to the participants within the environment used in the study, to become accustomed to the technique order, depth and stroke rate in the set massage routine.

3.2 *Main Study Research Design*

This study used 8 participants who were randomly allocated into two groups of 4. All aspects of the test procedure were completed in different locations in the National Indoor Athletics Centre (NIAC), Cardiff. The study lasted two weeks (Monday to Friday) with a week in between functioning as a “washout” period. A “washout” period is a time during which participants do not receive either treatment in an effort to eliminate carry over effects that the first treatment may have produced (Katz, 2006). Baseline measures of their hamstring flexibility were conducted at the start of both weeks (Monday) and retested at the end of each week (Friday). Anthropometric data was also collected prior to the study. For the first week, participants engaged in one of two interventions, a sports massage or a foam rolling intervention that lasted three days (Tuesday to Thursday). After the 7 day washout period, they engaged in the alternative treatment. The sports massage intervention involved a 20 minute controlled, manual massage to the hamstrings and the foam rolling intervention comprised of 20 minutes of controlled, self-delivered, hamstring foam rolling. During the test period, all participants were instructed to maintain their normal, daily routines but were not permitted to include any additional flexibility enhancing modalities into their programmes.

3.2.1 *Main Study Participants*

8 male sports students studying at Cardiff Metropolitan University volunteered as participants for this study. All participants were physically active within a team sport, free from injury throughout the whole test period and were not allowed to participate if a hamstring injury had been sustained in the last twelve months. Additionally, as an inclusion criteria measurement in order to be considered for the study, participants finger-ground distance had to be greater than 0cm (unable to touch the floor whilst bending forward), a valid test demonstrated to measure hamstring flexibility (Magnusson et al, 1997). All volunteers were chosen as they met the study criteria and were all easily accessible throughout the study period. Eligibility of the participants was determined through individual meetings prior to the study period.

Prior to the study commencing, participants were provided with an information sheet explaining, in writing, the study objectives and experimental procedure (Appendix A). A pre-test health questionnaire (Appendix B) and informed consent (Appendix C) was obtained on the first test day prior to involvement.

3.3 *Testing*

Testing was completed at the same time each testing day to ensure the participants were in a similar fluid and nutritional state (Gore, 2000). All participants were tested individually to avoid competitive results (Krautblatt and Krautblatt, 2007). Prior to testing, participants performed a 10 min, set warm up shown in table 1.0. The routine consisted of eleven dynamic stretching exercises of increasing intensity, shown to appropriately warm-up the hamstring muscles (Perrier, Pavol and Hoffman, 2011).

Table 1.0 Warm up utilised prior to testing

Dynamic warm up stretching exercises	
1	Easy skip with arm swings
2	Skip for distance using arms to drive forward
3	Skip for height using arms to drive upward
4	Backward run (extend heel backwards during stride)
5	Lateral low shuffle (back and forth-no walk-rest 20 seconds between reps)
6	Step into single leg Romanian dead lift
7	Walking diagonal lunges
8	High knee pulls (knee to chest, on toe)
9	Carioca (back and forth-no walk-rest 20 seconds between reps)
10	Straight leg strides (back and forth-no walk-rest 20 seconds between reps)
11	Gradual accelerations (1 x 50%, 1 x 75%, 1 x 90%) * Each exercise was performed twice over a distance of 18m. Unless specified otherwise participants walked back to the starting line between repetitions.

(Perrier, Pavol and Hoffman, 2011)

Participants were then tested on the subsequent field tests in the following order:

1) The Sit and Reach test
2) The Back Saver Sit and Reach Test
3) Active Knee Extension test

All the above field tests have been reported as reliable and valid measures of hamstring flexibility (Baltaci et al, 2003 and Gajdosik et al, 1983). Each participant was given consistent verbal encouragement for motivation (Escamilla, 2005) thus achieving their best performance.

Participants followed the exact procedures above for subsequent testing days.

3.3.1 *Anthropometric Data*

Anthropometric data for all participants was obtained on day one of the study period before the testing procedures began (see Appendix D). The participants' height was measured, without shoes, using a free-standing stadiometer (SECA, Model 321, Germany) to the nearest 0.5 cm and their body mass was also measured to one decimal place using calibrated scales (SECA, Model 770, Germany).

3.3.2 *Hamstring Flexibility Assessment*

All hamstring flexibility test procedures were performed in NIAC and a risk assessment of the testing environment was conducted (see Appendix E). Each participant was given three trials for each flexibility test where the mean result was taken to determine the performance score. The arithmetic mean was used as it clearly summarises the data and is easy to understand, interpret and compare (Field, (2000) and Bryman and Duncan Cramer, (2005)). The participants were allowed 30 secs between trials and a rest period of 2-3 mins between tests (Ayala et al, 2012). The protocols and environmental conditions for each test were the same for all test days to minimise variables that may affect the participants' performance (Gore, 2000). All tests were administered, measured and recorded by one tester who was familiar with all test procedures, in order to reduce risk of experimental errors and improve reliability of the test procedures (Coulson and Archer, 2009). The participants wore similar clothing and footwear for all testing days.

3.3.2.1 *Sit and Reach Test*

The sit and reach field test is the most common protocol used to measure hamstring flexibility (Ayala et al, 2012) using a standard sit and reach box. The box had an overall measuring scale ranging from 0cm-69cm with 15cm projecting out over the box toward the participant. Thus if the actual plane of the box was reached, the score would be 15cm. This test was performed using the procedures outlined in the ACSM manual (2006). For the start position, as illustrated in position A in figure 1.0, participants sat on the floor, without shoes, with knees fully extended and their soles of their feet in neutral dorsiflexion, flat against the box at 15cm. To assume an upright position, hips were flexed at approximately 90 degrees (Barlow et al, 2004). The participants reached forward slowly with both hands parallel, palms down, to a pain-free position. An isometric position was held for 2 secs, as shown in position B in figure 1.0, where the measurement was taken. Participants were instructed to exhale and drop their head between their arms when reaching forward (ACSM, 2006).

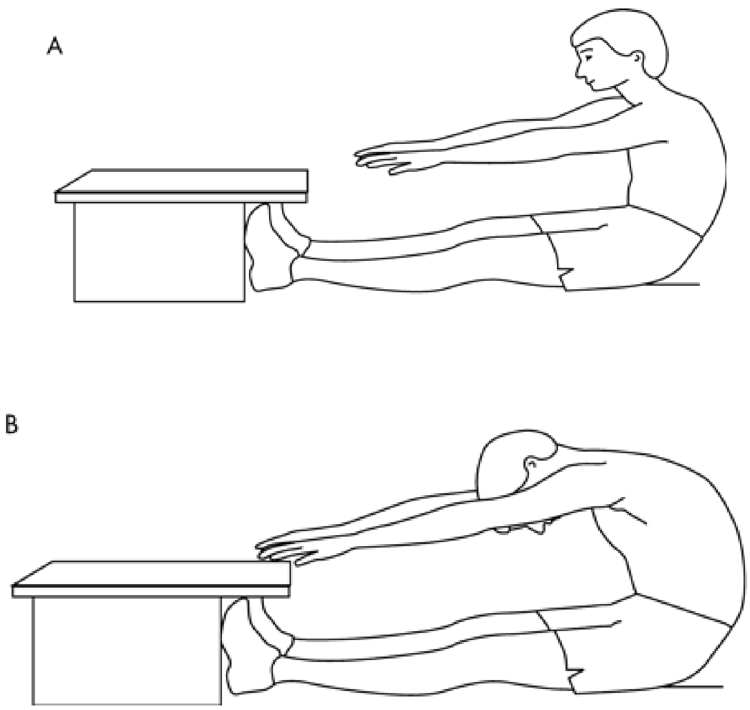

Figure 1.0 Illustration of the sit and reach test (Barlow et al, 2004)

3.3.2.2 *Back Saver Sit and Reach Test*

The procedures for the back saver sit and reach test are similar to that of the traditional sit and reach test, however hamstring flexibility of each limb is measured independently as opposed to simultaneous measurement of both limbs (ACSM, 2006). By testing one leg at a time, stress to the lower back and spine is reduced (Cailliet, 1998) and asymmetry in hamstring flexibility can be determined

(Meredith and Welk, 2010). The right leg was tested first followed by the left leg, alternating legs between trials. The non-test leg was flexed so that the sole of the foot was flat on the floor and 2-3 inches from the side of the extended test leg (Meredith et al, 2010). If necessary, the participant was allowed to move the bent knee aside when moving forward.

3.3.2.3 *Active Knee Extension Test*

Firstly, participants were instructed to remove footwear and then the anatomical landmarks, the greater trochanter of the femur, lateral epicondyle of the knee and lateral malleolus of the ankle were identified and marked and a line was drawn through all three. This line was removed with water and was redrawn for every test session. The right leg was tested first followed by the left, alternating legs between trials. Participants lay supine on a massage plinth with a neutral head position and both legs extended. To assume the start position, demonstrated in figure 2.0, the test leg was passively positioned with hip and knee at 90 degrees (Norris et al, 2005). Participants were instructed to place both hands on their femur to ensure it didn't move throughout the test. The non-test leg maintains full extension throughout the test by pushing heel away from body as described by Gore (200). The ankle of the test leg was relaxed in a plantar flexion position, as restrictive range of movement could occur with the ankle dorsiflexed (Martin, Jackson, Morrow and Liemohn, 1998). The test-leg was actively extended until a point where the femur begins to move from the vertical position.

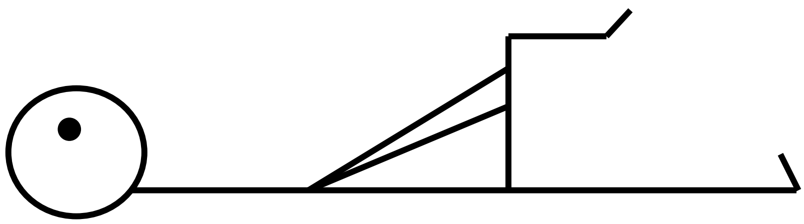

Figure 2.0 Illustration of the starting position for the active knee extension test

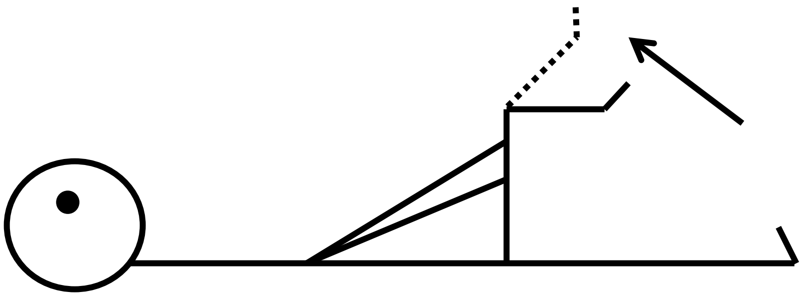

Figure 3.0 Illustration of the start to end position for the ankle knee extension

3.3.3 *Hamstring Flexibility Data Collection*

Data for both of the sit and reach tests was collected by measuring, in cms, the greatest distant point reached with the fingertips (ACSM, 2006) to the nearest 0.5cm, using the measurement scale on the box. If participants did not reach the measuring scale they were awarded a score of 0cm. For the active knee extension test, the angle of knee flexion (degrees) was measured using a standard goniometer (EMS Physion Limited, England).

3.4 *Data Analysis of all Main Study Tests*

Statistical analysis was performed within the software IBM Statistical Package for the Social Sciences (SPSS) and figures to represent data were created in Microsoft Excel. A one way repeated measures ANOVA was used to identify significant differences between pre and post hamstring flexibility measurements whilst a paired samples t-test was conducted to examine any differences between the effects of the interventions. Significance values was set at $p<0.05$. The mean and standard deviation was also calculated to determine a good representation of a value.

3.5 *Sports Massage Intervention*

Manual sports massage was administered by a qualified and insured sports massage therapist who was also the author and study design researcher. The massage intervention was undertaken in the Sports Massage clinic located within NIAC. Another risk assessment was undertaken for this environment (see Appendix F). The application involved a 20 min sports massage to the hamstrings muscles, 10 mins on both legs, a standard duration used throughout recent studies as identified by Hemmings et al (2000). The right leg was massaged first. A stop watch was used by the researcher to ensure standardisation of time (Hemmings et al, 2000) of the massage routine and of each massage technique to allow all treatments to be consistent. A metronome (Mobile Metronome for Android Version 1.2.4F) was also used to determine the speed of each stroke. The depth of massage given was of a consistent manner for each treatment and was intended to replicate that of the depth experienced during the foam rolling treatment. The massage plinth that was used was suitably positioned within the cubical and was set at an appropriate height to enable the therapist to move freely around the patient, work from different angles and apply body weight efficiently at all times (Cash, 1996). Prior to the massage treatment the therapist informed the participants, in detail, of the massage procedure that was to follow. Additionally the therapist communicated throughout the treatment to ensure care and safety of the client. The participants were instructed to inform the therapist immediately if any pain was felt. The therapist followed the set routine displayed in table 2.0.

Table 2.0 Sports massage routine

Techniques used	Time (Seconds)	Beats per minute
1) *Effleurage*	3 minutes	80
Flat Hand	30 seconds	Every 4 beats
"V"	30 seconds	Every 4 beats
Rotary	30 seconds	On the beat
Forearm Glide	30 seconds	Every 4 beats
Calm and Spindle	30 seconds	Every 4 beats
Opposing glide	30 seconds	Every 4 beats
2) *Petrissage*	30 seconds	On the beat
3) *Vibrations*	30 seconds	

* All effleurage techniques were performed three times before performing petrissage and vibrations

The massage techniques above are described (see Appendix G) and were applied using hypoallergenic oil (Biotone, USA) with the participants in a prone position.

3.6 *Foam Rolling Intervention*

The foam rolling intervention was administered by the participants themselves within NIAC. Prior to the engagement of the foam rolling treatment, participants familiarised themselves with the foam roller itself, technique, area and rate of application. The foam rollers used were of a rigid density with dimensions of 50cm in length and 15cm in diameter. The application involved 20 mins of foam rolling to the hamstring muscles, 10 mins to each leg, starting with the right leg. This time period reflected that of the massage treatment. However, the foam rolling routine consisted of 4 bouts of 2.5 mins of continuous foam rolling with 30 secs rest period between each bout to allow recovery of the arms from supporting body weight (Mohr, 2008). A stop watch was used to time each bout of foam rolling and rest period accurately and consistently. A metronome was also used to determine the speed of each roll, down and up, and was set at 80 beats per minute, to replicate the massage stroke speed. For the foam rolling technique shown in figure 4.0, participants sat on the floor with the foam roller placed underneath their hamstring, perpendicular to the body. The leg being foam rolled was extended with the ankle in a relaxed, plantar flexed position with the other leg flexed with the sole of the foot flat on the floor. The participants began the foam rolling movement at the ischial tuberosity and completed the movement at the popliteal fossa (Miller et al, 2006 and Mohr, 2008). The participants positioned their upper body at approximately 90 degrees to their lower body with extended arms placed behind the foam roller. Participants were instructed to allow as much pressure between the hamstring muscle and the foam roller as possible (Mohr, 2008). All foam roller routine sessions were supervised by the researcher to ensure correct technique was being used throughout.

Figure 4.0 Illustration of the hamstring foam rolling technique (Emmons, 2010)

CHAPTER FOUR
RESULTS

4.0 **Results**

This chapter demonstrates subject descriptive data and main study results obtained from the three physiological field tests, for both sports massage and foam rolling interventions, including mean (±SD) differences and statistically significant (*P*) statistics.

4.1 *Main Study Descriptive Data*

8 male sports students aged 21.75 ± 3.3 years, stature 181.69 ± 3.1 cm and weight 83.1 ± 9.4 kg all met the criteria specifications for this study.

4.2 *Main Study Results*

The mean and standard deviations for all three hamstring flexibility field tests for both pre and post testing are shown in table 3.0

Table 3.0 The mean and standard deviation (±SD) values for all flexibility test scores for each intervention

Intervention		Sit and Reach (cm)		Back Saver Sit and Reach (cm)				Active Knee Extension (deg)			
				Right		Left		Right		Left	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Sports Massage	Pre	2.96	3.69	4.50	3.71	3.94	3.99	121.96	7.18	124.67	7.58
	Post	5.21	2.74	5.75	3.32	5.27	3.13	126.29	4.70	128.96	5.92
Foam Rolling	Pre	3.73	3.29	3.83	2.49	3.04	2.57	120.08	7.20	121.29	8.12
	Post	4.50	3.10	5.25	3.17	5.15	3.71	128.96	7.25	129.67	6.99

The raw data main study results are displayed in (see Appendix H).

4.3 *Sit and Reach Test*

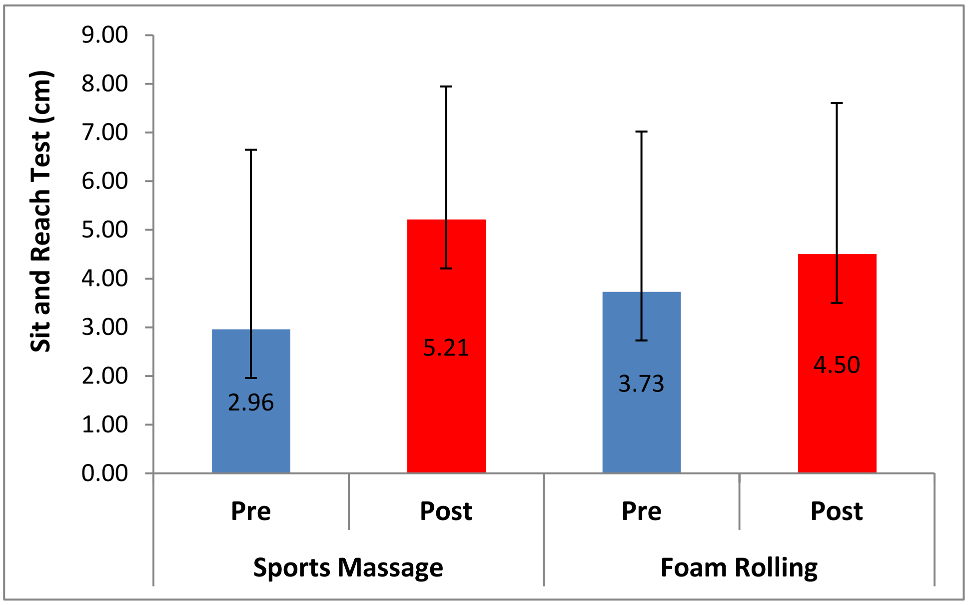

Figure 5.0 Displays the mean and standard deviation for intervention and time for the sit and reach test (cm)

Through the conduction of a one-way repeated measures ANOVA, it was identified that there was no significant difference ($p > 0.05$) between the ***Pre Sports Massage*** (x = 2.96cm) and ***Pre Foam Rolling*** (x = 3.73cm) sit and reach test performances. This established that participants commenced each intervention with similar individual baseline measures.

Additionally, the results of the one way repeated analysis of variance concluded that there were no significant differences ($p > 0.05$) between the ***Pre*** and ***Post*** sit and reach performances for both the ***Sports Massage*** (Pre = 2.96cm; Post = 5.21cm) and ***Foam Rolling*** (Pre = 3.73cm; Post = 4.50cm) interventions.

The results of a paired samples t-test, conducted on the difference between ***Pre*** and ***Post*** sit and reach performances for the sports massage intervention (mean change = 2.25 ± 2.25) and the foam rolling intervention (mean change = 0.77 ± 1.83), revealed that there were no significant differences ($t = 1.600$, $p > 0.05$) between the effects of each intervention.

4.4 Back Saver Sit and Reach Test

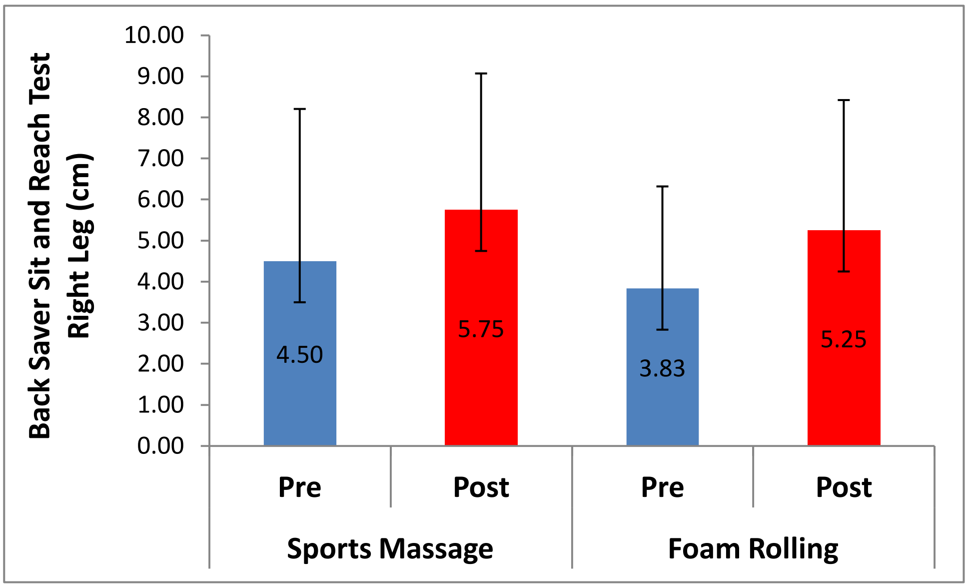

Figure 6.0 Displays the mean and standard deviation for intervention and time for the back saver sit and reach test (cm) for the right leg

Through the conduction of a one-way repeated measures ANOVA, the results demonstrated that there was no significant difference ($p > 0.05$) between the ***Pre Sports Massage*** (x = 4.50cm) and ***Pre Foam Rolling*** (x = 3.83cm) back saver sit and reach test performances for the right leg. This established that participants commenced each intervention with similar individual baseline measures.

Furthermore, the results of the one way repeated analysis of variance concluded that there were no significant differences ($p > 0.05$) between the ***Pre*** and ***Post*** back saver sit and reach performances for the right leg for both the ***Sports Massage*** (Pre = 4.50cm; Post = 5.75cm) and ***Foam Rolling*** (Pre = 3.83cm; Post = 5.25cm) interventions.

The findings of a paired samples t-test, conducted on the difference between ***Pre*** and ***Post*** back saver sit and reach performances for the right leg for the sports massage intervention (mean change = 1.25 ± 1.77) and the foam rolling intervention (mean change = 1.42 ± 1.76), revealed that there were no significant differences ($t = -.273$, $p > 0.05$) between the effects of each intervention.

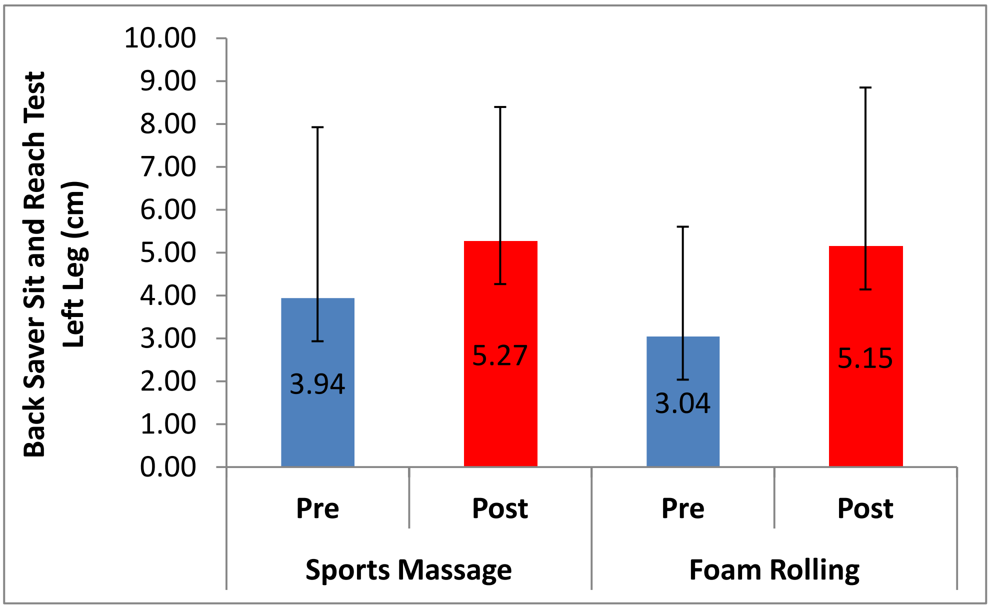

Figure 7.0 Displays the mean and standard deviation for intervention and time for the back saver sit and reach test (cm) for the left leg

Through the performance of a one-way repeated measures ANOVA, the results concluded that there was no significant difference (p > 0.05) between the ***Pre Sports Massage*** (x = 3.94cm) ***and Pre Foam Rolling*** (x = 3.04cm) back saver sit and reach test performances for the left leg. This established that participants commenced each intervention with similar individual baseline measures.

In addition, the results of the one way repeated analysis of variance demonstrated that there were no significant differences (p > 0.05) between the ***Pre*** and ***Post*** back saver sit and reach performances for the left leg for both the ***Sports Massage*** (Pre = 3.94cm; Post = 5.27cm) and ***Foam Rolling*** (Pre = 3.04cm; Post = 5.15cm)interventions.

The results of a paired samples t-test, conducted on the difference between ***Pre*** and ***Post*** back saver sit and reach performances for the left leg for the sports massage intervention (mean change = 1.33 ± 2.07) and the foam rolling intervention (mean change = 2.11 ± 2.3), revealed that there were no significant differences (t = -.949, p > 0.05) between the effects of each intervention.

4.5 *Active Knee Extension Test*

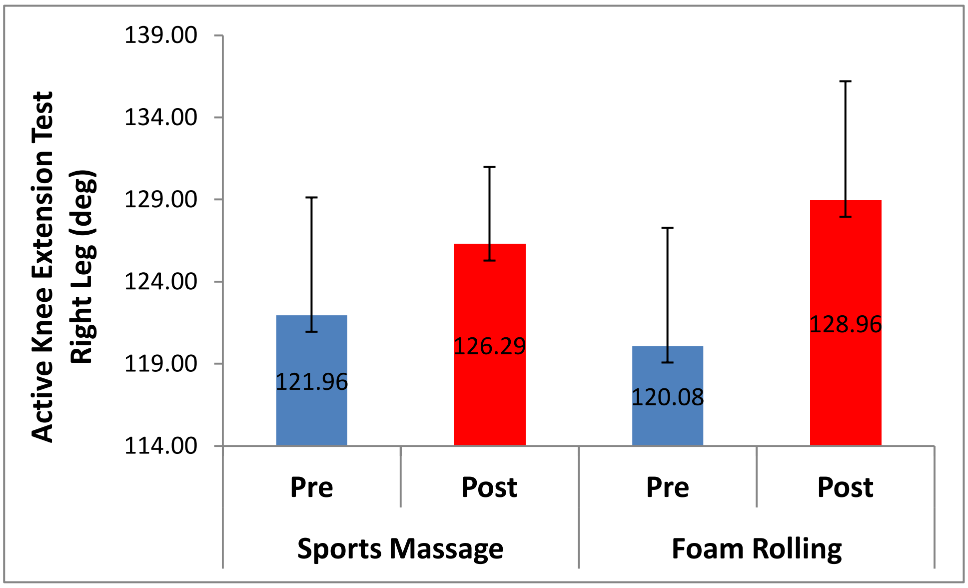

Figure 8.0 Displays the mean and standard deviation for intervention and time for the active knee extension test (deg) for the right leg

Through the performance of a one-way repeated measures ANOVA, the results identified that there was no significant difference ($p > 0.05$) between the ***Pre Sports Massage*** (x = 121.96°) and ***Pre Foam Rolling*** (x = 120.08°) active knee extension for the right leg. This established that participants commenced each intervention with similar individual baseline measures.

Additionally, the findings of the one way repeated analysis of variance showed that there were no significant differences ($p > 0.05$) between the ***Pre*** and ***Post*** active knee extension performances for the right leg for the ***Sports Massage*** (Pre = 121.96°; Post = 126.29°) intervention, however the ***Pre*** and ***Post*** active knee extension performances for the right leg for the ***Foam Rolling*** (Pre = 120.08°; Post = 128.96°) intervention was found to be significant ($p < 0.05$).

The results of a paired samples t-test, conducted on the difference between ***Pre*** and ***Post*** active knee extension performances for the right leg for the sports massage intervention (mean change = 4.33 ± 4.68) and the foam rolling intervention (mean change = 8.88 ± 4.75), identified that there were no significant differences (t = -1.765, p > 0.05) between the effects of each intervention.

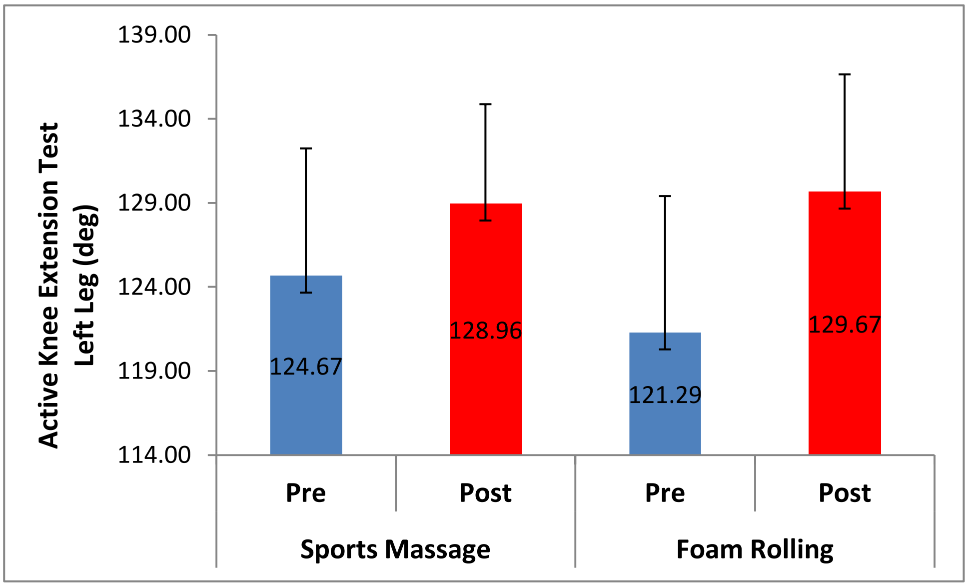

Figure 9.0 Displays the mean and standard deviation for intervention and time for the active knee extension test (deg) for the left leg

Through the conduction of a one-way repeated measures ANOVA, the results indicated that there were no significant difference (p > 0.05) between the ***Pre Sports Massage*** (x = 124.67°) and ***Pre Foam Rolling*** (x = 121.26°) active knee extension for the left leg. This established that participants commenced each intervention with similar individual baseline measures.

In addition, the results of the one way repeated analysis of variance revealed that there were no significant differences (p > 0.05) between the ***Pre*** and ***Post*** active knee extension performances for the left leg for the ***Sports Massage*** (Pre = 124.67°; Post = 128.96°) intervention, however the ***Pre*** and ***Post*** active knee extension performances for the left leg for the ***Foam Rolling*** (Pre = 121.29; Post = 129.67) intervention was statistically significant (p < 0.05).

The findings of a paired samples t-test, performed on the difference between ***pre*** and ***Post*** active knee extension performances for the left leg for the sports massage intervention (mean change = 4.29 ± 6.5) and the foam rolling intervention (mean change = 8.38 ± 4.81), identified that there were no significant differences (t = -1.388, $p > 0.05$) between the effects of each intervention.

CHAPTER FIVE
DISCUSSION

5.0 **Discussion**

The aim of this study was to compare the effects of sports massage and self-myofascial release (foam rolling) on hamstring flexibility of male athletes.

5.1 *Main Study Findings*

The results from the main study conclude that sports massage to the hamstring muscle group had no significant effect on improving hamstring flexibility in any of the test battery components. However foam rolling to the hamstring muscle group did show a significant effect on hamstring flexibility in the active knee extension test. No significant differences were found between the interventions.

5.2 *Research Question One*

Does the application of sports massage improve flexibility of the hamstring muscle group?

Based on the statistical results, the null hypothesis stated in chapter one has been accepted and the first hypothesis has been rejected. The findings of this study show that a 10 minute sports massage to the hamstring muscle groups over a three day period had no significant effect ($p > 0.05$) on flexibility. There was no significant increase in hamstring flexibility in both or either legs in the two sit and reach tests and the active knee extension test.

It could be suggested that no significant difference was found due to the small sample size (n = 8). However the results of this study are in agreement with studies of similar sample size (n = 11) and (n = 10) and massage routine (Barlow et al (2004) and Jourkesh (2007)). However these studies only investigated the short term effects of massage unlike this study that attempted to investigate these effects over a longer period of time. Conversely, in disagreement with this study's findings, Crosman et al (1984) found an increase in range of motion using a larger sample size (n = 34). Additionally, following two 5 minute massage sessions per week for three weeks, it was concluded that massage had significant effects on hamstring flexibility (Vennard, 2005).

It could also be proposed that physiological effects of sports massage do not exist. Authors have argued that benefits of massage are more psychological (Hemmings et al, 2000), however, massage has shown to be physiologically beneficial (Goats, 1994). Although, this study found massage to have no physiological effects on hamstring flexibility, generalisation cannot made without further research to state that sports massage does not have a significant effect on flexibility.

Despite the fact that massage routine in this study was specifically controlled to ensure consistency and reliability of treatments, this may have influenced the results obtained. It has been identified that there is no standard routine to follow for sports massage (Cash, (1996) and Mills and Parker-Bennett, (2004)) and it should depend on the individual needs of the client. A routine specific to the client's needs, working to eliminate specific tight areas within the hamstring muscle group may have changed the results.

Additionally, the findings may have been affected by the use of sports massage in isolation. It has been established that sports massage in conjunction with dynamic stretching improved hamstring flexibility (Cavalieri, 2001), therefore if sports massage was applied alongside another stretching treatment modality, the results may have shown greater significance and effect. Furthermore, massage was only performed to the hamstring muscle belly. A study conducted by Huang et al (2010) found that massage applied to the musculotendinous junction of the distal portion of the hamstrings improved range of motion. Thus massage to adjacent tissues or structures may have given more significant results.

5.3 *Research Question Two*

Does the application of foam rolling improve flexibility of the hamstring muscle group?

Based on the results of the statistical tests, the null hypothesis stated in chapter one has been rejected and the second hypothesis has been accepted. The results of this study demonstrate that a 10 minute application of foam rolling to the hamstring muscle group over a three day period had a significant effect ($p < 0.05$) on flexibility performance. For performance of the active knee extension test, there was a significant improvement in pre and posts scores, however this was not the case for the sit and reach tests.

Foam rolling employs specific mechanisms that could have contributed to its positive effect on hamstring flexibility. One potential theory involves changes in thixotrophic properties (fluid like form) of the fascia, allowing softening to occur when disturbed via heat and mechanical stress (Paolini, (2009) and MacDonald et al, (2012)) thus improving range of motion. Additionally, Paolini (2009) identified that authors have agreed that relieving spasm, breaking adhesions, increasing blood flow and lymphatic drainage through myofascial release all aid soft tissue extensibility. Furthermore, the vigorous and direct application of a foam roller using body weight pressure lengthens the muscle (MacDonald et al, 2012) it is in direct contact with. Therefore improvement within active knee extension performances may have been a result of this.

Studies in agreement with this study have also found foam rolling to be of benefit in improving range of motion (Mohr, (2008), D'Amico et al, (2011) and Macdonald et al, (2012)). Interestingly, Mohr (2008) found foam rolling to be of greatest benefit when used in conjunction with another stretching modality. In the present study, foam rolling was used in isolation and was shown to significantly affect active knee extension results only. Therefore if foam rolling was to have been used alongside another modality, results may have differed in the other field tests.

Similarly to the other intervention, the foam rolling routine was controlled and structured and therefore did not specifically meet the need of the participant. An alternative method could have been adopted which may have increased the significance of the results. This involves finding an area of tenderness and maintaining body weight over this point for 30 -90 seconds until discomfort begins to diminish and then repeat over other sensitive areas (Miller et al, 2006 and Paolini, 2009). Pausing creates focused pressure that will increase soft tissue extensibility (Paolini, 2009).

The reason why significant differences in hamstring flexibility in this study were shown through the active knee extension test only is worthy of a discussion. Previously, studies have reported that both of the sit and reach tests and the active knee extension test are reliable measures of hamstring flexibility (Simoneau, (1998), Baltaci, (2003) and Norris et al, (2005)), yet Davis et al (2008) found insufficient concurrent validity between the two, documenting that they should not be used interchangeably.

The active knee extension test is known as a gold standard measure for hamstring muscle length (Davis et al, 2008), yet the sit and reach test has indicated to measure hip and spine flexion exclusively (Sinclaire and Tester, 1993) due to the nature of the movement. Other variables and joint factors are purported to affect results of the sit and reach test including scapula abduction (Hopkins, 1981) and limb length proportion (Hopkins and Hoeger, 1992), signifying that results may not be a true representation of hamstring flexibility.

One main difference between the two tests that may have influenced the results in this study is the ankle position during the test. A dorsiflexed ankle performed in the sit and reach tests is deduced to add tension on the sciatic nerve and/or the fascial connections between the gastrocnemius and the hamstring muscles (Gajdosik, LeVeau and Bohannon (1985)), thus creating neural restrictions and invalid measurements of hamstring flexibility.

5.4 *Research Question Three and Four*

Is the application of sports massage more effective than the application of foam rolling in improving flexibility of the hamstring muscle group?

Is the application of foam rolling more effective than the application of sports massage in improving flexibility of the hamstring muscle group?

The ultimate aim of this study was to compare the effects of sports massage and foam rolling.

Based on the results of the statistical tests, both the third and fourth hypotheses stated in chapter one have been rejected. The findings from the paired t-tests indicate that there was no significant difference ($p > 0.05$) between the effects on hamstring flexibility of each intervention, thus neither intervention is more effective than the other. This was shown for all three field tests used in this study.

The findings of the magnitudes of change are misleading as statistically foam rolling improved hamstring flexibility as opposed to sports massage. Technically, the foam rolling was therefore a more effective treatment however this is not shown statistically. With regards to this study, focus is upon the fact that foam rolling did increase hamstring flexibility.

5.5 *Strengths*

5.5.1 *Research Study Design*

A main strength of this study was the use of a randomised crossover design. Firstly this design allows for a direct within-subject comparison to be made between the interventions as each subject serves as their own control (Chow and Liu, 2004), thus decreasing variability of the data and results. Furthermore Katz (2006) explains that this type of research design may increase subject motivation because subjects will be guaranteed to receive both treatments.

5.5.2 *Testing and Intervention Design*

A strength of the hamstring flexibility testing procedure was the inclusion of a familiarisation trial prior to the study period. A familiarisation session ensures that performance changes are not a result of learning (Moir, Button, Glaister and Stone, 2004), thus increasing the reliability of the results. In addition, the use of an appropriate and controlled warm up prior to testing confirmed the participants were sufficiently prepared.

Furthermore, both interventions of sports massage and foam rolling consisted of a standardised 20 minutes of application, 10 minutes on each leg. Unlike other studies that have attempted to compare the effects of different treatment modalities on hamstring flexibility (Witorsson- Moller et al 1983 and Cavalieri, 2001), the present study regulated the time variable of each intervention to allow for a true comparison to be made.

5.6 *Limitations*

5.6.1 *Main Study Subjects*

A small sample size (n = 8) was used within this study therefore generalisation to a wider population could not be made from the results found. If a larger sample size was to have been used by the author, a stronger analysis and more reliable and significant results could have been produced. As only male subjects were drawn upon for this study, the findings were bias and restricted to this gender. If both genders were to have been included, greater significance and practical implications of the results would have been established. Additionally, comparisons between genders could have been made and may have revealed other meaningful results as to the effects of sports massage and foam rolling on hamstring flexibility.

As an inclusion criterion for this study, subjects were required to be physically active within a team sport, therefore current level of activity participation, fitness level and sport varied between the participants. Due to this, frequency and intensity of participation differed and subsequently hamstring flexibility would have been directly influenced by their participation in sport. These factors would have influenced the standardisation of the data.

Complete control over the subjects for the duration of the study period would have been ideal however this was not possible, therefore the reliability of the study and overall results were compromised.

5.6.2 *Hamstring Flexibility Testing*

Firstly, although participants were instructed to keep exercise participation to a minimum on the days before testing and on the day prior to testing, participants may have engaged within physical activity during these periods which may have affected the results obtained during testing. Furthermore, even though hamstring flexibility testing was undertaken at the same time on each testing day, nutritional intake prior to testing was not monitored therefore this may also have affected the testing results. In addition, all the subjects performed the warm up together as a group. However, as a consequence of only one tester assessing each participant individually one after another, there was a possibility that the last subject to be tested had cooled down during the interim period.

For the sit and reach tests, the scoring system used was a main limitation. If the participants were unable to reach the measuring scale on the sit and reach box they were awarded a score of 0cm. However, if these participants did improve their hamstring flexibility over the study period as a result of the interventions but were still unable to reach the box post testing, they were again awarded a score of 0cm. As a consequence, this does not show in figures that the participant’s performance increased, therefore decreasing the validity and reliability of the data and results. Another measuring scale could have been used to provide negative scores to quantify scores below 0cm.

5.6.3 *Sports Massage Intervention*

The sports massage intervention within this study had some limitations. Despite the fact that the sports massage routine was administered by the same massage therapist and regulated through the use of a stopwatch and metronome, it could not be guaranteed that each subject received identical treatments. Massage is a very physical therapy and can be considered almost a sport itself (Cash, 1996). As the therapist was required to perform multiple treatments each day of the intervention period, slight differences in the pressure exerted via specific techniques may have occurred as a result of fatigue.

There also remains an unclear knowledge and understanding about the effects of different massage techniques (Weerapong et al, 2005) on flexibility performance. This made it difficult to identify the type of massage techniques required for team players to increase their hamstring flexibility. Also, for this study three specific techniques were used however, in clinical practice massage to the hamstring muscle group would likely to include a number of other techniques and methods (Jourkesh, 2007).

Additionally, some subjects within this study were accustomed to sports massage whilst others had not received a sports massage previously and were unfamiliar with the procedure. Although the massage routine was comprehensively explained to every participant, this could possibly have affected the results attained as the individuals who were used to receiving massage may have reacted differently to those who were not (Jönhagen et al, 2004).

Furthermore, therapist experience was not a variable controlled within this study. This subject has been an area for discussion with some authors. It is claimed that technique used depends on the experience of the therapist (Weerapong et al, 2005) and that therapist education and training may have impact on the effectiveness of massage. A study conducted by Moraska (2007) showed that a greater reduction in muscle soreness was achieved by therapists with the highest amount of training hours. Within this study, the sports massage therapist had no more than 200 hours of massage experience. This therefore may have influenced the effectiveness of the massage provided.

5.6.4 *Foam Rolling Intervention*

The foam rolling intervention within this study also had some limitations too. Due to the fact that the participants themselves executed foam rolling, the technique and pressure exerted differed for each individual. Curran, Fiore and Crisco (2008) identified that foam rolling technique has an impact on the level of pressure applied on the underlying tissues. As the technique demanded the use of the participant's hands to support their weight, technique may have altered due to fatigue therefore a decrease in pressure over the hamstring muscle group may have occurred during this intervention.

5.7 *Potential Improvements*

A few improvements, of the current study could be made in order to demonstrate more significant and reliable results. With regards to the main study participants, a larger sample size could be used involving both genders of similar sport participation and fitness level. Additionally, the inclusion of the sit and reach test should be reconsidered but a scale to quantify scores below 0cm is essential to provide accurate results of the interventions. In relation to the sports massage intervention, potential improvements include the use of a more experienced massage therapist. Improvements for the foam rolling intervention could include the measurement of pressure exerted through the foam roller onto the hamstring muscle group to ensure consistency.

5.8 *Practical Implications*

The most important finding to focus upon from this study that significantly contributes to literature is that foam rolling was effective in increasing hamstring flexibility. Athletes therefore seeking to improve flexibility of their hamstring muscles may benefit from the use of a foam roller within their daily athletic routines. Additionally, foam rolling may be used successfully in a clinical setting, as a stretching modality to treat athletes with tight hamstring muscles. Furthermore, although sports massage was shown to have no effect on hamstring flexibility in this study, its use in sport should not be disregarded as favourable literature exists.

5.9 *Future Recommendations*

For future research the following areas need to be addressed:

Firstly, with regards to hamstring flexibility testing further research needs to be undertaken on factors that may influence the reliability and validity of existing testing protocols.

Future research in relation to sport massage is required in order to determine not only physiological benefits but psychological effects also. Standardisation of variables included within a sports massage routine is necessary in order for scientific results and findings to be accurately analysed and to allow for true comparisons to be made. One variable that exclusively needs depth in further research is sports massage techniques and their benefits.

Finally, the growth of literature surrounding the benefits of foam rolling on flexibility requires scientific evidence to support findings. It may be of interest to investigate the effects of foam rolling on flexibility of other body parts to expand knowledge and understanding of this area.

CHAPTER SIX
CONCLUSION

6.0 **Conclusion**

This study investigated the comparison of sports massage and self-myofascial release (foam rollers) on hamstring flexibility of male athletes. The results showed a statistically significant difference ($p < 0.05$) in performance of the active knee extension test (°) through the use of foam rollers, therefore, H2 was accepted. Furthermore, sports massage was shown to have no significant effect ($p > 0.05$) on hamstring flexibility and no significant difference was found between the two interventions, hence H1, H3 and H4 were rejected.

From the present study, it is clear that accurate knowledge and understanding of sports massage and foam rolling has been found to be challenging due to scarcity of quality research and lack of scientific evidence.

Sports massage has a long tradition of use in sports medicine and the science behind it is of great interest to many populations including athletes, coaches and sports physiologists (Callaghan, 1993 and Moraska, 2005). Specifically, massage is believed to increase flexibility (Findlay, 2010) however evaluation of this is made difficult by a small body of literature and those that are available fail to define critical elements. This therefore has led to inadequate declaration and poor appreciation of its clinical effectiveness. Studies on the effects of sports massage on flexibility are controversial (Crosman et al (1984) and Barlow et al, (2004)) and may be due to methodological deficiencies. Future research should look to focus on the standardisation and validity of variables within a massage routine.

With regards to foam rolling, recent claims suggest foam rollers are a useful stretching technique in order to treat individuals with a variety of soft tissue conditions including muscle tightness (Miller et al, 2006). The findings from the present study through the use of the active knee extension test are in agreement with this statement. Furthermore, despite foam rolling having an effect on hamstring flexibility, myofascial release should not replace traditional therapy techniques but should supplement and enhance them as a complementary approach (Barnes, 2009).

Even though statistically the magnitudes of the effects of both interventions on hamstring flexibility were not found to be different, this was not the case as in actual fact sports massage was shown to have no effect on flexibility whereas foam rolling did. Due to the fact that comparisons and relationships between these modalities have not been explored within the literature, it is difficult to comprehend the findings of this study.

The current state of sports massage and foam rolling research indicates potential for therapeutic benefits to the athlete however the conduction of further scientific evidence is required to validate the physiological benefits of sports massage, support the findings in relation to foam rolling and evaluate differences between the two modalities.Future research will also hope to conduct studies that will remove the limitations identified in the current study to evidently confirm and extend understanding in this field.

CHAPTER SEVEN
REFERENCES

7.0 **References**

Alter, M.J. (2004). *Science of Flexibility* (3rd ed). Champaign, IL: Human Kinetics.

American College of Sports Medicine. (2006). *Acsm's guidelines for exercise testing and Prescription* (7th ed). Baltimore, MD: Lippincott, Williams and Wilkins.

Anderson, B. Pearl, B. Burke, E. & Galloway, J. (2007). *Getting Back in Shape: 32 workout programs for lifelong fitness* (3rd ed). Bolinas, California: Shelter Publications, Inc.

Ayala, F. Sainz de Baranda, P. De Ste Croix, M. & Santonja, F. (2012). Absolute reliability of five clinical tests for assessing hamstring flexibility in professional futsal players. *Journal of Science and Medicine in Sport,* **15**, 142-147.

Ayers, S.F. & Sariscsany, M. (Eds). (2011). *Physical Education for Lifelong Fitness – The Physical Best Teacher's Guide* (3rd ed). Champaign, IL: Human Kinetics.

Baechle, T.R. & Earle, R.W. (Eds). *Essentials of Strength Training and Conditioning* (3rd ed). Champaign IL: Human Kinetics.

Baltaci, G. Un, N. Tunay, V. Besler, A. & Gerçeker, S. (2003). Comparison of three different sit and reach tests for measurement of hamstring flexibility in female university students. *British Journal of Sports Medicine,* **37**(1), 59-61.

Bandy, W.D, Irion, J.M, & Briggler, M. (1998). The Effect of Static Stretch and Dynamic Range of Motion Training on the Flexibility of the Hamstring Muscles. *Journal of Orthopaedic & Sports Physical Therapy*, **27**(4), 295-300.

Barlow, A. Clarke, R. Johnson, N. Seabourne, B. Thomas, D. and Gal, J. (2004). Effect of massage of the hamstring muscle group on performance of the sit and reach test. *British Journal of Sports Medicine*, **38**, 349-351.

Barnes. J. F (2009). Myofascial Release. In Davis. C. M. Davis (Ed). *Complementary Therapies in Rehabilitation* (pp. 89). United States of America: SLACK Incorporated.

Benjamin, P.J. & Lamp, S.P. (2005). *Understanding Sports Massage* (2nd ed). Champaign, IL: Human Kinetics.

Blum, J. W, & Beaudoin, C. M. (2000). Does Flexibility Affect Sport Injury and Performance? *Journal of Sports Medicine and Physical Fitness,* **45**(3), 295-300.

Bozic, P.R. Pazin, N.R. Berjan, B.B. Planic, N.M. & Cuk, I.D. (2010). Evaluation of the field tests of flexibility of the lower extremity: Reliability and the concurrent and factorial validity. *Journal of Strength and Conditioning Research,* **24**(9), 2523-2531.

Bradley, P. S. & Portas, M. D. (2007). The relationship between preseason range of motion and muscle strain injury in elite soccer players. *Journal of Strength and Conditioning Research,* **21**(4), 1155–1159.

Brooks, J.H,M, Fuller, C.W, Kemp, S.P,T, & Reddin, D.B. (2006). Incidence, Risk, and Prevention of Hamstring Muscle Injuries in Professional Rugby Union. *The American Journal of Sports Medicine,* **34**(8), 1297-1306.

Brummitt, J. (2008). The role of massage in sports performance and rehabilitation: Current evidence and future direction. *North American Journal of Sports Physical Therapy,* **3**(1), 7-21.

Bryman. A. and Cramer, D. (2005). *Quantitative Data Analysis with SPSS 12 and 13.* Sussex: Routledge.

Cailliet, R. (1988). *Low back pain syndrome*. Philadelphia: F. A. Davis.

Callaghan, M. J. (1993). The role of massage in the management of the athlete: a review. *British Journal of Sports Medicine,* **27**(1), 28-33.

Cash, M. (1996). *Sport & Remedial Massage Therapy.* London: Ebury Press.

Cavalieri, J. C. (2001). Effect of dynamic stretching, hot pack, and massage application on hamstring flexibility. Springfield College School of Graduate Studies.

Chandler, J. T, and Brown, L. E. (2008). *Conditioning for Strength and Human Performance.* Philadelphia: Lippincott Williams & Wilkins.

Cherkin, D.C. Sherman, K.J. Kahn, J. Wellman, R. Cook, A.J. Johnson, E. Erro,
J. Delaney, K. & Deyo, R.A. (2011). Comparison of the Effects of 2 Types of Massage and Usual Care on Chronic Low Back Pain. *Annals of Internal Medicine,* 155, 1-9.

Chow, S. & Liu, J. (2004). *Design and Analysis of Clinical Trials* (2nd ed). New Jersey: John Wiley & Sons, Inc.

Clarke, M.A. Lucett, S.C. & Kirkendall, D.T. (2009). *NASM Essentials of Sports Performance Training.* Philadelphia: Lippincott Williams & Wilkins.

Cornbleet, S. L. & Woolsey, N. B. (1996). Assessment of Hamstring Muscle Length in Scholl-aged Children Using the Sit-and-Reach Test and the Inclinometer Measure of Hip Joint Angle. *Physical Therapy,* **76**(8), 850-855.

Coulson, M. & Archer, D. (2009). *Practical Fitness Testing.* London: A&C Black Publishers Ltd.

Craib, M.W, Mitchell, V.A, Fields, K.B, Cooper, T.R, Hopewell, R. & Morgan, D.W. (1996). The association between flexibility and running economy in sub-elite male distance runners. Medicine and science in sports and exercise, **28**, 737-743.

Crosman, L.J, Chateauvert, S.R, and Weisberg, J. (1984). The Effects of Massage to the Hamstring Muscle Group on Range of Motion. *The Journal of Orthopaedic and Sports Physical Therapy,* **6**(3), 168 – 172.

Cross, K.M, Gurka, K.K, and Conaway, M. (2010). Hamstring Strain Incidence Between Genders and Sports in NCAA Athletics. *Athletic Training & Sports Health Care,* **2**(3), 124-130.

Curran, P.F. Fiore, R.D. and Crisco, J.J. (2008). A Comparison of the Pressure Exerted on Soft Tissue by 2 Myofascial Rollers. *Journal of Sport Rehabilitation,* **17** (4), 432-442.

D'Amico, A. & Morin, C. (2011) Effects of Myofascial Release on Human Performance. In association with Bridgewater State University

Davis, S.D. Quinn, R.O. Whiteman, C.T. Williams, J.D. & Young, C.R. (2008). Concurrent validity of four clinical tests used to measure hamstring flexibility. *Journal of Strength and Conditioning Research,* **22**(2), 583-588.

Decoster, L.C. Cleland, J. Altieri, C. & Russell, P. (2005). The Effects of Hamstring Stretching on Range of Motion: A systematic Literature Review. *Journal of Orthopaedic & Sports Physical Therapy,* **35**(6), 377-387.

Dunford, M. & Doyle, J. A. (2008). *Nutrition for Sport and Exercise.* Belmont: Thomson Wadsworth.

Emmons, R. (2010). *Roll release foam roller techniques .* Calgary, Alberta: Roll Release Inc.

Escamilla, R. F. (2005). Exercise Testing and Prescription. In: Speer, K. P. (ed). *Injury Prevention and Rehabilitation for Active Older Aldults.* Champaign IL: Human Kinetics, pp. 19-48.

Findlay, S. (2010). *Sports Massage.* Champaign, IL: Human Kinetics.

Field, A. (2000). *Discovering Statistics using SPSS for Windows.* London: SAGE Publications Ltd.

Gajdosik, R. & Lusin, G. (1983). Reliability of an Active-Knee-Extension Test. *Physical Therapy,* **63**(7), 1085-1088.

Gajdosik, R.L. LeVeau, B.F. & Bohannon, R.W. (1985). Effects of Ankle Dorsiflexion on Active and Passive Unilateral Straight Leg Raising. **65**(10), 1478 – 1482.

Galloway, D.R.S., & Watt, M. J. (2004). Massage provision by physiotherapists at major athletic events between 1987 and 1998. *Journal of Sports Medicine*, **38**(2), 235 – 237.

George, W.J., Andrew, C., Tunstll, D.C., Rodger, E., Tepe, P.h.D., Clayton, D., Skaggs, DC. (2006). The Effects of Active Release Technique on Hamstring Flexibility: A Pilot Study. *Journal of Manipulative and Physiological Therapeutics,* **29**(1), 224 – 227.

Gleim, G.W, Stachenfeld, N.S. & Nicholas, J.A. (1990). The influence of flexibility on the economy of walking and jogging. *Journal of Orthopaedic Research,* **8**, 814-823.

Goats, G. C. (1994). Massage-the scientific basis of an ancient art: part 2. Physiological and therapeutic effects. *British Journal of Sports Medicine,* **28**(3), 153-156.

Gore, C. J. (2000). *Physiological Tests for Athletes.* Australia: Human Kinetics.

Grenier, S.G. Russell. C. & McGill. S.M. (2003). Relationships Between Lumbar Flexibility, Sit-and-Reach Test, and a Previous History of Low Back Discomfort in Industrial Workers. *Canadian Journal of Applied Physiology,* **28**(2), 165-177.

Halbertsma, P,K,J. van Bolhuis, I,A. & Goeken, N,H,L. (1996). Sports Stretching: Effect on Passive Muscle Stiffness of Shorts Hamstrings**.** *Archives of physical medicine and rehabilitation,* **77**, 688-692.

Hartig, D.E. & Henderson, J.M. (1999). Increasing Hamstring Flexibility Decreases Lower Extremity Overuse Injuries in Military Basic Trainees. *The American Journal of Sports Medicine,* **27**(2), 173-176.

Hemmings, B. Smith, M. Graydon, J. & Dyson, R. (2000). Effects of massage of physiological restoration, perceived recovery, and repeated sports performance. *British Journal of Sports Medicine,* **34**, 109-115.

Holt, J. Holt, L.E. & Pelham, T. W. (1996). Flexibility redefined. In *Proceedings XIII International Symposium on Biomechanics in Sports* (Edited by T. Bauer), pp. 172. Lakhead University, Thunder Bay, Ontario Canada.

Hopkins, D. R. (1981). The relationship between selected anthropometric measures and sit-and-reach performance. Paper presented at the American Alliance of Health, Physical Education, Recreation and Dance. National Measurement Symposium, Houston, Texas.

Hopper, D. Conneely, M. Chromiak, F. Canini, E. Berggren, J. & Briffa, K. (2005). Evaluation of the effect of two massage techniques on hamstring muscle length in competitive female hockey players. *Physical Therapy in Sport,* **6**, 137-145.

Hopper, D. Deacon, S. Das, S. Jain, A. Riddell, D. Hall, T. & Briffa, K. (2005). Dynamic soft tissue mobilisation increases hamstring flexibility in healthy male subjects. *British Journal of Sports Medicine,* **39**, 594-598.

Howley, E. T. and Thompson, D. L. (2012). *Fitness Professional's Handbook* (6th ed). Champaign, IL: Human Kinetics.

Huang, S.Y. Di Santo, M. Wadden, K.P. Cappa, D.F. Alkanani, T. & Behm, D. G. (2010). Short-duration massage and the hamstrings musculotendinous junction induces greater range of motion. *Journal of Strength and conditioning Research,* **24** (7), 1917-1924.

Hui, S. S. & Yuen, P. K. (2000). Validity of the modified back-saver sit-and-reach test: a comparison with other protocols. *Medicine and Science in Sports and Exercise,* **32**(9), 1655 – 1659.

Hunter, A.M. Watt, J.M. Watt, V. & Galloway, S.D.R. (2006). Effect of lower limb massage on electromyography and force production of the knee extensors. *British Journal of Sports Medicine,* **40**, 114-118.

Jones, B.H. Cowan, D.N. Tomlinson J.P. Robinson J.R. Polly, D.W. & Frykman, P. N. (1993). Epidemiology of injuries associated with physical training among young men in the army. *Medicine and science in sports and exercise,* **25**(2), 197-203.

Jones, J.C. Rikli, R.E. Max, J. & Noffal, G. (1998). The Reliability and Validity of a Chair Ait-and-Reach Test as a Measure of Hamstring Flexibility in Older Adults. *American Alliance for Health, Physical Education, Recreation and Dance,* **69**(4), 338-343.

Jones, B.H. & Knapik, J.J. (1999). Physical Training and Exercise-Related Injuries. *Sports Medicine,* **27**(2), 111-125.

Jönhagen, S. Ackermann, P. Eriksson, T. Saartok, T. and Renström, P. A. F. H. (2004). Sports Massage After Eccentric Exercise. *The American Journal of sports Medicine,* **32**(6), 1499 – 1503.

Jourkesh, M. (2007). The effect of massage on performance of the sit and reach test in adolescent soccer players. *Medicina Dello Sport*, **60**(2), 151– 155.

Junge, A. Cheung, K. Edwards, T. & Dvorak, J. (2004). Injuries in youth amateur soccer and rugby players – comparison of incidence and characteristics. *British Journal of Sports Medicine,* **38**(2), 168-172.

Katz, M. H. (2006). *Study Design and Statistical Analysis.* New York: Cambridge University Press.

Knopf, K. (2011). *Foam Roller Workbook.* Berkeley: Ulysses Press.

Knudson, D. V. (2007). *Fundamentals of Biomechanics (*2nd ed). New York: Springer Science+Business Media, LLC.

Knudson, D.V, Magnusson, P, and McHugh, M. (2000). Current Issues in Flexibility Fitness. *President's Council on Physical Fitness and Sports Research Digest*, **3**(10).

Krautblatt, C. & Krautblatt, C. (2000). *Fitness ABC's: Training Manual and Fitness Instructor Course.* Utah: ECKO House Publishing.

Liemohn, W. Martin, S.B. & Pariser, G. L. (1997). The Effect of Ankle Posture on Sit-and-Reach Test Performance. *Journal of Strength and Conditioning Research,* **11**(4), 239-241.

Liemohn, W. Sharpe, G.L. and Wasserman, J.F. (1994). Criterion Related Validity of the Sit-and-Reach Test. *Journal of Strength and conditioning Research,* **8**(2), 91-94.

López-Miñarro, P.A. and Rodríguez-García, P.L. (2010). Hamstring muscle extensibility influences the criterion-related validity of sit-and-reach and toe-touch tests. *Journal of Strength and Conditioning Research,* **24**(4), 1013-1018.

López-Miñarro, P.A. Sáinz de Baranda Andújar, P. and Rodríguez-García, P.L. (2009). A comparison of the sit-and-reach test and the back-saver sit-and-reach test in university students. *Journal of Sports Science and Medicine,* **8**, 116-122.

López-Miñarro, P.A. Sáinz de Baranda Andújar, P. Rodríguez-García, P.L. & Toro, E. O. (2007). A comparison of the spine posture among several sit-and-reach test protocols. *Journal of Science and Medicine in Sport,* **10**(6), 456-462.

MacDonald, G. Penney, M. Mullaley, M. Cuconato, A. Drake, C. Behm, D.G. & Button, D.C. (2012). An acute bout of self myofascial release increases range of motion without a subsequent decrease in muscle activation or force. *Journal of Strength and Conditioning Research.* ISSN 1064-8011.

Mackinnon, L.T. Ritchie, C.B. Hooper, S.L. & Abernethy, P.J. (2003). *Exercise Management – Concepts and Professional Practice.* Champaign, IL: Human Kinetics.

Magnusson, S.P. Simonsen, E.B. Aagaard, P. Boesen, J. Johannsen, F. & Kjaer, M. (1997). Determinants of musculoskeletal flexibility: viscoelastic properties, cross-sectional area, EMG and stretch tolerance. *Scandinavian journal of medicine & science in sports*, ***7***(4), 195-202.

Martin, S. B. Jackson, A. W. Morrow, J. R. & Liemohn, W. P. (1998). The Rationale for the Sit and Reach Test Revisted. *Measurement in Physical Education and Exercise Science,* **2**(2), 85-92.

Meredith, M.D. & Welk, G.J. (Eds). (2010). *Fitnessgram & Actvitygram Test Administration Manual* (Updated 4th ed). Champaign IL: Human Kinetics.

Miller, J. K. and Rockey, A. M. (2006). Foam rollers show no increase in the flexibility of the hamstring muscle group. *Journal of Undergraduate Research IX,* 1-4.

Mills, R. and Parker-Bennett, S. (2004). *Sports Massage.* Oxford: Heinemann Educational Publishers.

Mohr, A. R. (2008). Effectiveness of foam rolling in combination with a static stretching protocol of the hamstrings. Bachelor of Science in Athletic Training. Southeast Missouri State University. Cape Girardeau, Missouri.

Moir, G. Button, C. Glaister, M. & Stone, M. H. (2004). Influence of familiarization of the reliability of vertical jump and acceleration sprinting performance in physically active men. *Journal of Strength and Conditioning Research,* **18**(2), 276-280.

Moraska, A. (2005). Sports massage: A comprehensive review. *Journal of Sports Medicine and Physical Fitness,* **45**(3), 370-380.

Moraska, A. (2007). Therapist education impacts the massage effect on postrace muscle recovery. *Medicine & Science in Sports & Exercise,* **39**(1), 34-37.

Norris, C.M. & Matthews, M. (2005). Inter-tester reliability of a self-monitored active knee extension test. *Journal of Bodywork and Movement Therapies,* **9**(4), 256-259.

Palmer, G. and Reid, A. (2009). *Elite Performance Running*. London: A & C Black Publishers Ltd.

Perrier, E.T. Pavol, M.J. & Hoffman, M.A. (2011). The acute effects of a warm-up including static or dynamic stretching on countermovement jump height, reaction time, and flexibility. *Journal of Strength and Conditioning Research,* **25**(7), 1925-1931.

Planteleimon, B. Panagiotis, I. & Fotis, B. (2010). Evaluation of hamstring flexibility by using two different measuring instruments. *Sport Logia,* **6**(2), 28-32.

Paolini, J. (2009). Review of Myofascial Release as an Effective Massage Therapy Technique. *Athletic Therapy Today,* **14**(5), 30-34.

Robertson, A. Watt, J.M. & Galloway, S. D. R. (2004). Effects of leg massage on recovery from high intensity cycling exercise. *British Journal of Sports Medicine,* **38**, 173-176.

Robertson, M. (2008). *Self-Myofascial Release – Purpose, Methods and Techniques.* Indianapolis, IN: Robertson Training Systems.

Robinson. K. (2004). The effect of sports massage on hamstring flexibility and athletic performance. Cardiff School of Sport.

Shellock, F.G, & Prentice, W.E. (1985). Warming-Up and Stretching for Improved Physical Performance of Sports-Related Injuries. *Sports Medicine* **2**, 267-278. ADIS Press Limited.

Shrier, I. & Gossal, K. (2000). Myths and Truths of Stretching. *The Physcician and Sports Medicine,* **28**(8), 57 – 63.

Simoneau, G.G. (1998). The Impact of Various Anthropometric and Flexibility Measurements on the Sit-and-Reach Test. *Journal of Strength and Conditioning research,* **12**(4), 232-237.

Sinclair, A., & Tester, G. (1993). The Sit and Reach Test-What Does it Actually Measure?. *ACHPER National Journal*, ***40***, 8-8.

SPS Limited (2003). *Sports Massage Diploma.*

Standaert, C.J. & Herring, S.A. (2003). Physiological and functional Implications of injury. In W.R. Frontera (Ed) *Rehabilitation of Sports Injuries*. USA : Blackwell Science Ltd.

Standley, R.A. Miller, M.G. & Binkley, H. (2010). Massage's effect on injury, recovery, and performance: A review of techniques and treatment parameters. *Strength and Conditioning Journal,* **32**(2), 64-67.

Taimela, S. Kujala, U.M. & Osterman, K. (1990). Intrinsic risk factors and athletic injuries. *Sports Medicine,* **9**, 205-215.

Thacker, S.B, Gilchrist, J. Stroup, D,F, & Kimsey, C.D. (2004). The Impact of Stretching on Sports Injury Risk: A systematic Review of the Literature. *Medicine and science in sports and exercise,* **36**(3), 371-378.

Vennard, K. J. (2005). The effects of massage on hamstring flexibility. Master of Arts (Kinesiology), Sam Houston State University, Hunstville, Texas.

Watt, J. (1999). *Massage for sport*. Marlborough: Crowood Press.

Weerapong, P. Hume, P.A. & Kolt, G.S. (2004). Stretching: Mechanisms and benefits for sport performance and injury prevention. *Physical Therapy Reviews,* **9**(4), 189-206.

Weerapong, P. Hume, P.A. & Kolt, G.S. (2005). The Mechanisms of Massage and Effects on Performance, Muscle Recovery and Injury Prevention. *Sports Medicine,* **35** (3), 235-256.

Wells, R.F & Dillon, E.K. (1952). The sit-and-reach test – A test of back and leg flexibility. *Research Quarterly,* **23**, 115- 118.

Wiktorsson-Moller, M. Oberg, B. Ekstrand, J. and Gillquist, J. (1983). Effects of warming up,massage and stretching on range of motion and muscle strength in lower extremity. *The Journal of Sports Medicine,* **11**(4), 249-252.

Witvrouw, E. Danneels, L. Asselman, P. D'Have, T. & Cambier, D. (2003). Muscle Flexibility as a Risk Factor for Developing Muscle Injuries in Male Professional Soccer Players: A Prospective Study. *The American Journal of Sports Medicine,* **31**(1), 41-46.

Woods, K. Bishop, P. & Jones E. (2007). Warm-Up and Strecthing in the Prevention of Muscular Injury. *Sports Medicine,* **37**(12), 1089-1099.

Youdas, J.W. Krause, D.A. & Hollman, J.H. (2008). Validity of hamstring muscle length assessment during the sit-and-reach test using an inclinometer to measure hip joint angle. *Journal of Strength and Conditioning Research,* **22**(1), 303-309.

APPENDICES

APPENDIX A

Cardiff School of Sports Ethics Committee
Research Participant Information Sheet

Project Title: The comparison of Sports Massage and Self-Myofascial Release on hamstring flexibility of male athletes.

This document provides information on:

1) the background and aim of the research study,
2) my role as the researcher,
3) your role as a participant,
4) benefits of taking part,
5) how data will be collected, and
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 involved in the project, and to promote transparency in the research process.

1) Background and aims of the research

Although both sports massage and self-myofascial release are readily available as methods of stretching, they have not been compared and their relationships have not been reported. Therefore, the aim of the present study will be to explore the effects of sports massage on hamstring flexibility compared to self-myofascial release.

2) My role as the researcher

The project involves me (Hannah Price) conducting two interventions, a sports massage and a foam rolling intervention. Field tests of hamstring flexibility will also be conducted.

3) Your role as the participant

Your role as the participant is to engage within both interventions in addition to engaging within hamstring flexibility testing.

4) Benefits of taking part

The information we obtain from this study will allow better insight into the comparison of sports massage and self-myofascial release on hamstring flexibility. The outcome will conclude which stretching modality, sports massage or self-myofascial release, is more effective in improving flexibility in athletes. From this we will aim to understand more about the effects of these techniques on athletic performance. We will be happy to share this information to any of the participants of this study.

5) How data will be collected

Hamstring flexibility will be measured using three different indirect tests. These tests will be the sit and reach test, the back saver sit and reach test and the active knee extension test. For both sit and reach tests, scores in centimetres (cm) will be collected and for the active knee extension test a goniometer will assess knee flexion angle in degrees.

6) How the data / research will be used

In agreeing to become a *voluntary* participant, you will be allowing me to use your results to make conclusions. Your personal data will be anonymous and will not be reported alone, but within the total sample of participants.

Your rights
Protection to privacy
Contact

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

Hannah Price
Cardiff School of Sport
Cardiff Metropolitan University
CF236XD, United Kingdom
Email: ST10001825@cardiffmet.ac.uk

APPENDIX B

Health Screening Questionnaire

Cardiff Metropolitan University
Prifysgol Fetropolitan Caerdydd
UWIC

The purpose of this questionnaire is to determine suitability of participation within the research study. All information recorded on this form will be treated with the utmost confidentiality and will be stored in a secure place and made available to you at any time.

Name: …………………………………………………….
Date of Birth: ……………………………
Address: …………………………………………………
……………………………………………………………..
……………………………………………………………..

Gender: ………………………….
Occupation: …………………….
Postcode: ………………………..
Tel No: ……………………………

Name of GP/Consultant: ……………………………...
Name of Practice: ……………………………………...
Address: …………………………………………………
……………………………………………………………..
……………………………………………………………..
……………………………………………………………..
……………………………..

Postcode:
Tel No:

Please tick the appropriate box: **Yes** **No**

1. Have you suffered any illnesses in the last 12 months?
If yes, please give details below.

2. Are you currently taking any prescribed medication?
If yes, please give details below.

3. Are you subject to any medical condition?
If yes, please give details below.

4. Have you undergone any surgery in last 12 months or are you carrying any injury?
If yes, please give details below.

5. Do you have any allergies?
If yes, please give details below.

6. Is there anything else of relevance I should be aware of?
If yes, please give details below.

Signature: …………………………………………………….   **Date**: …………………

APPENDIX C

Cardiff Metropolitan Informed Consent Form

Cardiff Metropolitan University
Prifysgol Fetropolitan Caerdydd
UWIC

CSS Reference No:
Title of Project: The comparison of Sports Massage and Self-Myofascial Release on hamstring flexibility of male athletes
Name of Researcher: Hannah Price

Participant to complete the following section. Please initial each box

1. I confirm that I have read and understood the Participant Information Sheet dated ………………. for this research study. I have had the opportunity to consider the information provided, ask any questions and have had these answered satisfactorily. ☐

2. I understand that my participation within this study 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 no be affected. ☐

4. I understand that information from this study may be used for reporting purposes, but I will remain anonymous. ☐

5. I agree to take part in this study on the effects of sports massage on hamstring flexibility compared to self-myofascial release. ☐

Name of Participant: ______________________________
Signature of Participant: ______________________________ Date: ______________

Name of person taking consent: ______________________________
Signature of person taking consent: ______________________________ Date: ______________

* When completed, one copy for participant and one copy for researcher's files.

APPENDIX D

Individual (mean ± SD) anthropometric data for all participants used in the main study

Participant	Age	Height (cm)	Weight (kg)	Gender
1	23	182	84.2	M
2	19	177	73.7	M
3	20	183	80.5	M
4	23	180	75.7	M
5	21	186.5	86.3	M
6	20	183	82.3	M
7	29	178.5	103.9	M
8	19	183.5	78.2	M
Mean	21.75	181.69	83.1	
(±SD)	3.3	3.1	9.4	

APPENDIX E

□□□ . RISK ASSESSMENT (RA99)		Page 1 (V3/07)	
School / Unit and Area:	SCRaM	**Assessment Number:**	
Risk Assessment undertaken by: Recommended to be 2 or more people	Hannah Price		
Description of the work activity being assessed:	Dynamic hamstring warm up and hamstring flexibility testing		
Persons Affected:	Staff [ ] Students [X] Others [ ]		
Details of Others:			

	Hazards Identified Please provide details of the hazards associated with the area or task. **EXAMPLES INCLUDE:** Working at height, Manual Handling, Electricity, Fire, Noise, Contact with moving parts of machinery, Dust etc	**Risk Rating without Controls** The **R**isk **R**ating and Degree of Risk are determined by multiplying the **S**everity of injury by the **L**ikelihood of occurrence. Please see UWIC Risk Rating Matrix for details			
		S	**L**	**RR**	**Degree of Risk**
1	Risk of obstacles being within the working area	1	1	**1**	**Low**
2	Risk of damage to testing equipment	0	1	**0**	**No action required**
3	Risk of pain during hamstring flexibility testing	1	2	**2**	**Low**
4					
5					
6					
7					
8					
9					
10					
Example - 1. Risk of Fire Occurring (Office)		5	3	15	Unacceptable

Once all potential hazards have been identified and a Risk Rating has been applied, please go to page 2 and provide details of the control measures required to reduce the risk to an acceptable level

□□□ . RISK ASSESSMENT (RA99)							Page 2 (V3/07)
Controls to be Applied: **Examples Include:** Elimination, Substitution for something less hazardous, Barriers or fixed guards, standard operating procedures and personnel protective equipment		**Date Applied**	**Risk Rating with Controls Applied:**				
			S	**L**	**RR**	**Degree of Risk**	
1	Area was checked and free of any hazardous objects	21.01.13	1	1	**1**	**Low**	
2							
3	Testing procedure was supervised and explained thoroughly	21.01.13	1	1	**1**	**Low**	
4							
5							
6							
7							
8							
9							
10							
1.	Store all combustible and flammable material away from obvious ignition sources. Provide safe access and egress and ensure all staff are aware of the UWIC fire evacuation procedure	07/06/07	5	1	5	Moderate	
Date of First Assessment:	21.01.13	Review Date of overall Assessment:	21.01.13				

APPENDIX F

□□□ . RISK ASSESSMENT (RA99)		Page 1 (V3/07)	
School / Unit and Area:	SCRaM	**Assessment Number:**	
Risk Assessment undertaken by: Recommended to be 2 or more people	Hannah Price		
Description of the work activity being assessed:	Sports Massage		
Persons Affected:	Staff [ ]	Students [X]	Others [ ]
Details of Others:			

	Hazards Identified Please provide details of the hazards associated with the area or task. **EXAMPLES INCLUDE:** Working at height, Manual Handling, Electricity, Fire, Noise, Contact with moving parts of machinery, Dust etc	**Risk Rating without Controls** The **R**isk **R**ating and Degree of Risk are determined by multiplying the **S**everity of injury by the **L**ikelihood of occurrence. Please see UWIC Risk Rating Matrix for details			
		S	**L**	**RR**	**Degree of Risk**
1	Risk of participants being allergic to the massage oil	1	3	**3**	**Low**
2	Risk of massage table collapsing	1	1	**1**	**Low**
3	Risk of sports massage being painful	1	3	**3**	**Low**
4	Risk of obstacles being within working area	1	1	**1**	**Low**
5					
6					
7					
8					
9					
10					
	Example - 1. Risk of Fire Occurring (Office)	5	3	15	Unacceptable

Once all potential hazards have been identified and a Risk Rating has been applied, please go to page 2 and provide details of the control measures required to reduce the risk to an acceptable level

☐☐☐ . RISK ASSESSMENT (RA99)							Page 2 (V3/07)
Controls to be Applied: **Examples Include:** Elimination, Substitution for something less hazardous, Barriers or fixed guards, standard operating procedures and personnel protective equipment		Date Applied	Risk Rating with Controls Applied:				
			S	L	RR	Degree of Risk	
1	Sports massage therapist used hypoallergenic oil	22.01.13	1	1	**1**	**Low**	
2	Sports massage table was in good condition and set at correct height	22.01.13	1	1	**1**	**Low**	
3	Qualified sports massage therapist used only	22.01.13	1	1	**1**	**Low**	
4	Area was checked and free of any hazardous objects	22.01.13	1	1	**1**	**Low**	
5							
6							
7							
8							
9							
10							
1.	Store all combustible and flammable material away from obvious ignition sources. Provide safe access and egress and ensure all staff are aware of the UWIC fire evacuation procedure	07/06/07	**5**	**1**	**5**	**Moderate**	
Date of First Assessment:	22.01.13	Review Date of overall Assessment:	22.01.13				

APPENDIX G

Technical description of massage techniques used in the sports massage routine

Flat hand	*The skin is stroked with constant pressure towards the heart. Both hands stretch out flat ensuring fingers are closed together. Place hand closest to client and place the other hand on top ensuring both hands are pointing upwards on the hamstring. Transfer weight forward to maintain pressure required.*
“V”	*The skin is stroked with constant pressure towards the heart. With both hands make a large “V” shape between index finger and thumb. Place the hand furthest away from the client in the “V” shape made by the inside hand. Push hands up along the hamstring. Transfer weight forward to maintain pressure required.*
Rotary	*An adaptation of the “V” technique. With both hands make a large “V” shape between index finger and thumb. Place the hand closest to the client on the hamstring. Push hand up along the hamstring Near the end of the stroke sweep fingers in whilst other hand is starting at the distal end of the hamstring. Transfer weight forward to maintain pressure required.*
Forearm Glide	*Using outside part of the ulna to sweep up and outwards. Transfer weight forward to maintain pressure required.*
Calm and Spindle	*One hand is position in a fist like shape whilst grasping the thumb of the other hand and push up along hamstring. Transfer weight forward to maintain pressure required.*
Opposing Glide	*Using both palms of both hands push down then away from each other. When pushing down transfer weight onto balls of feet.*
Petrissage	*Both hands inwardly moving in a circular movement with intersect. Point of intersection finger and thumb pinch together. Transfer weight forward to maintain pressure required.*
Vibrations	*Shaking a massage usually at its distal tendon.*

(SPS LTD, 2003)

APPENDIX H

Individual (mean ± SD) raw data of the main study

	Sit and Reach (cm)				Sit and Reach - Back Saver (cm)								Active Knee Extension (°)							
Participant	Week 1		Week 2		Week 1				Week 2				Week 1				Week 2			
	Pre	Post	Pre	Post	Pre		Post		Pre		Post		Pre		Post		Pre		Post	
					R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
1	0.83	5.17	0.83	2.50	9.83	8.67	10.00	7.67	5.50	3.17	5.33	3.83	120.00	120.67	123.67	127.00	135.67	139.00	143.67	144.67
2	1.50	4.83	3.17	4.33	3.17	2.33	5.50	4.33	3.83	3.67	3.83	3.33	122.00	126.00	127.33	129.67	124.67	125.33	132.67	131.00
3	0.00	4.17	0.00	2.83	0.17	0.17	4.33	4.50	1.17	0.17	4.33	5.00	112.67	115.33	119.00	120.33	115.33	116.00	125.33	125.00
4	0.00	0.00	0.00	0.00	1.83	1.17	0.33	0.00	0.00	0.00	0.00	0.00	126.33	134.33	125.67	129.00	113.67	113.00	124.00	124.67
5	8.00	9.67	11.17	9.00	8.00	8.33	10.00	12.00	10.50	11.50	10.50	10.67	120.00	119.67	124.67	126.33	132.67	134.33	130.67	132.67
6	4.33	3.50	3.83	6.50	4.33	2.83	4.67	4.33	4.33	3.00	6.17	5.83	118.67	118.67	123.33	127.00	115.33	119.33	128.67	136.33
7	7.83	5.17	2.00	4.17	3.17	2.83	4.50	3.67	2.83	1.50	3.50	3.33	118.00	122.33	124.00	124.33	116.67	117.33	122.00	121.33
8	5.67	8.00	4.33	7.83	4.67	3.33	9.33	9.00	3.33	3.17	5.67	5.83	114.67	116.33	134.00	134.33	130.00	130.00	133.33	135.33
Mean	3.52	5.06	3.17	4.65	4.40	3.71	6.08	5.69	3.94	3.27	4.92	4.73	119.04	121.67	125.21	127.25	123.00	124.29	130.04	131.38
(±SD)	3.38	2.90	3.64	2.98	3.16	3.13	3.43	3.71	3.17	3.61	2.96	3.04	4.22	6.12	4.28	4.08	8.87	9.41	6.86	7.61