To investigate whether sprint-specific stretches are more effective when compared to standard dynamic stretches at enhancing sprint performance

**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.

**Introduction and literature review**
To include: outline of context (theoretical/conceptual/applied) for the question; analysis of findings of previous related research including gaps in the literature and relevant contributions; logical flow to, and clear presentation of the research problem/question; an indication of any research expectations, (i.e., hypotheses if applicable).
To include: details of the research design and justification for the methods applied; participant details; comprehensive replicable protocol.

### Results and Analysis

To include: description and justification of data treatment/ data analysis procedures; appropriate presentation of analysed data within text and in tables or figures; description of critical findings.

### Discussion and Conclusions

To include: collation of information and ideas and evaluation of those ideas relative to the extant literature/concept/theory and research question/problem; adoption of a personal position on the study by linking and combining different elements of the data reported; discussion of the real-life impact of your research findings for coaches and/or practitioners (i.e. practical implications); discussion of the limitations and a critical reflection of the approach/process adopted; and indication of potential improvements and future developments building on the study; and a conclusion which summarises the relationship between the research question and the major findings.

### Presentation

To include: academic writing style; depth, scope and accuracy of referencing in the text and final reference list; clarity in organisation, formatting and visual presentation

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2 This form should be used for both quantitative and qualitative dissertations. The descriptors associated with both quantitative and qualitative dissertations should be referred to by both students and markers.

2 There is scope within qualitative dissertations for the RESULTS and DISCUSSION sections to be presented as a combined section followed by an appropriate CONCLUSION. The mark distribution and criteria across these two sections should be aggregated in those circumstances.
TO INVESTIGATE WHETHER SPRINT-SPECIFIC STRETCHES ARE MORE EFFECTIVE WHEN COMPARED TO STANDARD DYNAMIC STRETCHES AT ENHANCING SPRINT PERFORMANCE.

(Dissertation submitted under the discipline of Physiology and Health)

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ACKNOWLEDGEMENTS

I would like to thank Dr. Michael G. Hughes for his assistance of this research, in particular for his vast knowledge, statistical prowess, invaluable time and sense of humour.

Secondly I would like to thank all the participants who volunteered for this study. I would like to thank Mark Jones, as without his continued enthusiasm and willingness to help; this study would have not been possible. A vital part of this research was understanding how to assemble and operate all equipment, for this I extend my gratitude to Mr. M. Stembridge.
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ABSTRACT

Within sport warm up precedes almost every athletic performance, the effectiveness of warm up can determine how prepared an athlete is for the performance ahead, and subsequently how well they perform. One of the major factors within warm up is stretching. The purpose of this study was to determine the effect of sprinting specific dynamic stretches on the fifty metre sprint performance. Nine undergraduate sport students participated within the study. Three different stretch protocols, Sprint Specific Stretching (SSS), Non Specific Dynamic Stretching (NSD) or Non Quadriceps Dynamic Stretching (NQD); were performed in a randomised repeated measures design. Following a standardised one kilometer warm up, participants completed one of the three stretch protocols, followed by two fifty metre stride outs. A two minute rest period was observed prior to the first of the two fifty metre sprints and in between sprints. There were no significant differences in fifty metre sprint times between the three stretch protocols (p≤ 0.05). There were no significant differences in stride frequency, stride length, and ground contact time between the three stretch protocols between twenty and thirty metres of the sprint (p≤ 0.05). When the sprint times were split into ten metre splits the results show that within the first ten meter split, the NQD stretch protocol was significantly faster than the SSS protocol. Between ten and twenty meters, the SSS stretch protocol was significantly faster than both the NQD and NSD stretch protocol. The NSD stretch protocol was significantly faster than the SSS stretch protocol between thirty and forty metres. The SSS stretch protocol was significantly faster than the NQD stretch protocol between forty and fifty metres, (all p≤ 0.05). Although fifty metre sprint performance was not found to be improved, the SSS protocol did yield significantly faster ten metre split times over two of the ten metre splits. Due to the positioning of the Optojump system, it is unclear as to why these results occurred, as stride length, stride frequency and ground contact time were unable to be recorded over these distances. In order to understand why the SSS was faster over these two ten metre sections of the fifty metre sprints, the Optojump system must be positioned in order for stride frequency, stride length and ground contact time to be recorded.
CHAPTER I
INTRODUCTION
1. Introduction
Preparation within any aspect of sport is of high importance. Within all levels of sport, warm up is the most common form of preparation; it is a widely accepted practice preceding nearly every athletic event (Smith, 1994; Bishop, 2003). Previous research (Behm and Chaouachi, 2011) has highlighted multiple stages to warm up, an aerobic activity, a type of stretching, and some kind of sport specific activity. Warm up influences performance by a variety of mechanisms, for example increased blood flow to muscles, elevation of baseline oxygen consumption, and increased nerve conduction rate (Ross and Leveritt, 2001; and Scheurmann 2002). The aim is to increase body temperature by one to two Celsius and to affect performance (Bishop, 2003). From previous research findings, it is apparent that not every warm up, including the stretching it incorporates, is beneficial for every kind of sport performance. In order for warm ups to aid the performance that succeeds them, they must be specific to that performance type.

The role warm up has on sprinting has been subject to various research, with an aim to gain an understanding of which warm up protocol will yield greatest performance. Within sprinting, the race is often won by the smallest time margins, and having an in depth understanding of which warm up yields greatest performance will only be beneficial to performers.

Previous studies (Brown et al, 2008; Yaichareon, 2012) have separated warm up into two types, and researched the effects of each type on sports performance. The two types of warm up identified are passive warm up and active warm up. Based on this classification, there have been numerous studies into the effects of each type of warm up on performance (Faigenbaum et al, 2005; McMillian et al, 2006; Yaichareon, 2012). Gregson et al. (2002) reported passive warm up may be detrimental to long term performance (‘≥5 minutes’ Bishop 2003), may improve intermediate performance (‘≥ 10 seconds, but ≤ 5 minutes’ Bishop, 2003), and does not improve isometric force within short term performance. Short term performance, defined by Bishop (2003) as ‘≤5 minutes’ (e.g. sprinting), can improve following active warm up (Mohr et al, 2003; Brown et al, 2008). In a short term performance event such as sprinting, the previous findings indicate an active warm up would yield the greatest performance (Goodwin, 2002).
Studies by Little and Williams (2006), Sekir et al. (2009) and Andrejić et al. (2011), all presented findings that showed stretching improved short term performance (e.g. sprinting). These findings justify the use of stretching within warm up. However, within these studies findings, it is apparent that certain types of stretching may cause a drop in performance rather than aid it. Therefore it is relevant to understand what types of stretching are effective, in order to gain further knowledge of how specific stretch types affect different performance types.

The most common types of stretching are Static Stretching, Dynamic Stretching and Proprioceptive Neuromuscular Facilitation (PNF) (Amako et al., 2003). Static stretching, defined as ‘slow or passive stretching, a slow deliberate movement is used to stretch the muscle.’ (Amako et al., 2003). Dynamic stretching defined as ‘the dynamic stretching technique involves the use of bouncing or jerking type motion to stretch a muscle group.’ (Amako et al., 2003). PNF is defined as ‘a combination of steps: a static stretch, an isometric contraction and relaxation, and then another static stretch’ (Amako et al., 2003). Each stretch type will have certain exercise types in which it will be able to aid performance; however there will be other performance types which it may inhibit. Due to sprint races being decided by such small margins, knowing which stretch type is most effective for sprint performance could lead to performers winning races, where they used to lose.

Fletcher and Anness (2007) investigated the effect of static and dynamic stretch protocols on performance. The dynamic stretches used were designed to mimic the actions within a sprint, as well as stretching the musculature used in sprinting, thus making the stretch specific to the sprint performance. By incorporating stretches that mimic the sprint cycle, it made those stretches specific to the exercise that succeeded them. When compared to static and static dynamic stretch protocols, stretches specific to the movements occurring within sprinting were significantly faster (Fletcher and Anness, 2007). Although the results of Fletcher and Anness (2007) suggest performance specific stretches yield greater performance in sprinting, the results lack a comparison to a non-specific set of dynamic stretches. As a result further research is required in order to fully understand whether performance specific stretches improve sprint performance. Previous evidence has found that static
stretching prior to sprinting may be detrimental to performance (Fletcher and Jones, 2004; Little and Williams, 2006; Sayers et al., 2008; Sim et al., 2009). Therefore the results of the study may not show that the stretches were specific to sprinting, instead the result of static versus dynamic stretching.

From the previous literature on this area it is clear that dynamic stretching in warm up results in greater sprint performance. The results from Fletcher and Anness (2007) suggest that specific stretching may be able to increase performance further; however the area lacks significant research to be able to draw a conclusion on its effectiveness. In order to understand whether specific stretching does improve performance, a study which compares sport specific dynamic stretches to non-specific dynamic stretches could be undertaken. Therefore the aim of this study is to investigate whether sprint-specific stretches are more effective than standard dynamic stretches at enhancing sprint performance. It is hypothesised that there will be a significant improvement in the stretches specific to sprinting compared to the nonspecific stretches.
CHAPTER II
LITERATURE REVIEW
2. Literature Review

2.1. Warm Up

This paper is aimed to research the effect of warm up, specifically the role stretch type, has on sprint performance. Warm prior to performance is a universally accepted practice; its aim is to prepare the athlete both physically and mentally for optimum performance (Young and Behm, 2002). Lack or incomplete warm ups can lead to higher risk of injury (Rokka et al., 2007 and Soligard et al., 2010), therefore understanding what a correct warm up entails is very important. Young and Behm (2002) stated that within warm up a low intensity aerobic exercise is performed, followed by stretching of the muscle used in the subsequent activity. The type of low intensity aerobic exercise and stretch type that yields greatest performance must be known in order for optimal performance to be achieved, as well as decreasing the risk of injury within sprinting.

2.1.1 Warm up Types

Previous studies (Bishop et al., 2001; and Gregson et al. 2002) have researched the effects of the different types of warm up on performance. Bishop (2003) categorised each study by the type of mode of activity employed within its method and whether it was short term, intermediate or long term performance. From previous literature, it was observed that passive warm up did not improve, and may be detrimental to long term performance, defined by Bishop (2003) as ‘≥5 minutes’. Passive warm up may improve intermediate performance (‘≥ 10 seconds, but ≤ 5 minutes’ Bishop, 2003), however it did not improve isometric force in short term performance (‘≤ 10 seconds’ Bishop, 2003), as shown in Skein et al. (2012). Results displayed that both muscular voluntary torque and muscular activation were reduced following a passive warm up; suggesting active warm up may result in improved results in short term performance. These findings in particular may be very important into research of the effect of warm up in sprint performance.

Sprinting is a short term maximal exercise; undergoing a warm up which results in a decreased muscular voluntary torque and muscular activation therefore has the potential to decrease performance (Skein et al., 2012). Within Bezodis et al. (2009) four elite athletics coaches identified the start of a race as the most important part of a sprint; one coach highlighted that the race can be over after the first two meters if
the start is not correct. Within a sprint start athletes are required to explode out of their blocks as fast and as powerfully as possible; thus requiring both high muscle activation and muscular voluntary torque. The nature of a sprint start implies that an active warm up may yield to improve performance, as neither variable is inhibited.

2.1.2 Stretching within Warm Up
Peak power, mean power or time to reach peak power were all significantly different when stretching either statically, dynamically or by proprioceptive neuromuscular function (Franco et al., 2012). Each stretch type was undergone prior to Wingate test performance. From the results it was clear that different types of stretching as well as warm up type affect certain aspects of sport performance. Franco et al. (2012) is supported by the findings of Andrejić et al. (2011). The results revealed that no stretching resulted in the slowest fifteen meter sprint performance, thus showing the relevance and benefits of stretching within warm up. The findings made by Franco et al. (2012) and Andrejić et al. (2012) are all supported by studies (Little and Williams, 2006; Sekir et al., 2009; Andrejić et al, 2012.) who all found improved performance following a stretch protocol. These findings support why stretching is present within warm up, and provide evidence that performance can be improved as a result. However, within the findings it is apparent that certain types of stretching may cause a drop in performance rather than aid it. This is shown in Andrejić et al. (2012) who found there to be a significant difference in mean power output (Watts), when comparing results from a dynamic stretch protocol and a PNF protocol. Therefore it is relevant to understand how each type of stretching either improves or inhibits the performance which succeeds it.

2. 2 Stretch Types - Individual Stretch Type Performance

2.2.1 Static Stretching
Static stretching has been shown to increase the range of motion around the joint, prevent injury, decrease muscle soreness and improve performance (Behm and Chaouachi 2011). The improvement in performance has been attributed to the
increased ability to reach or stretch during sport as well as decreased resistance within the muscle (Young and Warren, 2007). However Static stretching does not lead to an increase in performance for all exercise types, as shown in Andrejić et al. (2011). The results showed vertical jump and long jump were both significantly reduced following high volume static stretching. Following the stretch protocols, the times of four repeated fifteen meter sprints was significantly increased, reducing performance. Static stretching produced significantly slower ten meter sprint times when compared to a dynamic stretch protocol. Winchester et al. (2008) support the findings made by Andrejić et al. (2011) when comparing static stretching to a non-stretch group, those who undertook static stretching produced significantly slower twenty and forty meter sprint times. Both Sayers et al. (2008) and Sim et al. (2009) discovered similar findings and concluded that static stretching prior to sprinting, compromises performance. Nelson et al. (2007) highlighted that when the quadriceps were stretched statically, sprint time was increased, even though it is one of the prime movers involved in sprinting; a point which must be subject to further investigation. Fletcher and Jones (2004) attributed the decrease in sprint performance after static stretching due to a decrease in the musculotendinous units (MTU) stiffness. The amount of elastic energy ('energy stored within a muscle with the capacity to do work because of its position or form' Hammil and Knutzen, 2003) stored in the MTU is a function of its stiffness (compliance) (Fletcher and Anness, 2007). Decreased MTU stiffness is caused due to the myotatic reflex within static stretching. The myotatic reflex occurs during static stretching when mechanoreceptors within the muscle react to the stretching muscle. A reflexive inhibition of both agonistic muscles is produced which decreases the MTU stiffness (Fletcher and Anness, 2007). As a result of decreased MTU stiffness the muscle is able to store less elastic energy in the eccentric phases of movement, leading to a less efficient force transfer from the muscle to the tendon.

From the overview of literature it is clear that static stretching may be detrimental to sprint performance. Andrejić et al. (2011) produced further evidence which suggests static stretching decreases performance in vertical and long jumps also. A decrease in performance following static stretching is associated with the decrease in MTU stiffness which results in a decrease of force transfer between the muscle and
tendon. Static stretching may be better suited to long term performance where the contractions are not maximal.

2.2.2 Dynamic stretching
From undergoing dynamic stretching the facilitation of power, sprint and jump performance have been recorded (Samson et al. 2012). Dynamic stretches involve stretching using specific movements found within the succeeding exercise. Examples include running high knees, cross body leg raises and walking lunges.

Previous research shows that after a dynamic stretch warm up, both eccentric and concentric contractions were significantly stronger within both hamstrings and quadriceps when compared to a static stretch warm up (Sekir et al., 2010). Previous findings displayed that following dynamic stretching there was a significant increase in the performance of three squat jumps, and three counter movement jumps (Carvalho et al., 2012). However despite the benefits of dynamic stretching on other performance variables, previous results indicate the performance which gains the greatest improvement due to dynamic stretching is sprinting (Fletcher and Jones, 2004; Little and Williams, 2006; Fletcher and Anness, 2007; Samson et al., 2012).

Fletcher and Jones (2004) stated the reason why dynamic stretching leads to greater sprint performance, is due to the rehearsal of specific movements that are used within sprinting. Within dynamic stretching the stretch speed is higher than that of static stretching and PNF. Unlike static stretching the myotatic reflex is not inhibited allowing the reflex within dynamic stretching to be faster, which could potentially cause an increase in the MTU stiffness (Fletcher and Anness, 2007). The increased speed of the myotatic reflex aids the muscle in proprioception and preactivation, this then allows for increased performance by allowing optimum switching from eccentric to concentric muscle contraction. By increasing the speed of contraction, such as those found in dynamic stretching, Fletcher and Anness (2007) suggested there is potential for an increase speed of the action potential. Little and Williams (2006) discussed the reason why dynamic stretching improved sprint performance within their study; facilitated motor control may be occur due to the rehearsal of specific movements. Increase in muscle blood flow and elevations in the core or peripheral temperature have been cited as possibly increasing the sensitivity of the nerve
receptors, which could possibly lead to more rapid muscle contractions (Little and Williams, 2006).

Both Fletcher and Jones (2004) and Little and Williams (2006) cite the rehearsal of specific movement patterns within dynamic stretching as a possible mechanism of improving performance. The rehearsal of the specific movement patterns may lead to facilitated motor control, which may lead to faster muscular contractions. From the findings one is able to determine that dynamic stretching has the potential to increase muscular contraction speed.

2.2.3 Proprioceptive Neuromuscular Facilitation

PNF stretching is used mainly to increase the range of motion about a joint (Jordan, 2012). Within PNF, the aim is to activate the Golgi tendon organ, a mechanoreceptor which is sensitive to tension within the muscle (Fletcher and Anness, 2007). When stimulated it causes the muscle to reflexively relax and therefore increases the range of motion. However although PNF increases the range of motion around a joint, performance after undergoing PNF is not always improved.

After PNF, peak power and mean power were significantly lower when compared to a dynamic stretch protocol (Franco et al., 2012). Franco et al. (2012) reported that after PNF there is a possibility for a change in the length in the fascicles within the muscles, leading to a shift in the length – tension muscle curve. This results in the muscle working in a range of reduced ability to generate force. Franco et al. (2012) proposed that after undertaking PNF the stiffness of the MTU was decreased, similar to the effect of static stretching. The results of Marek et al. (2005) show that PNF reduced mean power output and peak torque, supporting the findings made by Franco et al. (2012).

However within Marek et al. (2005) PNF stretching showed increases in both the active and passive range of motion, shown by increases in stride length and hip flexion, highlighting its potential benefits to performance. Caplan et al. (2009) replicated these results and observed an increase of 7.6% in hip flexion following PNF. Within Caplan et al. (2009) PNF was also shown to alter stride length, an increase of 9.1%. However, these findings were after a five week stretch protocol therefore cannot be compared to previous findings, as PNF was not performed.
immediately prior to performance. Although the results from Caplan et al. (2009) and Marek et al. (2005) show that PNF may be able to benefit sprint performance, due to an increase of stride length and hip flexion.

From the literature it is apparent that PNF does not lead to an increase in short term performance when performed prior to exercise. However, PNF has been shown to improve variables which have the potential to increase short term performance (stride length increase). Therefore PNF should not be performed directly before short term exercise, as along with static stretching, it results in decreasing the force of muscular contractions.

2.3. Specific Stretching
Within previous literature there are examples of protocols which have incorporated stretches that are specific to the movement which succeeds them (Fletcher and Anness, 2007; Samson et al., 2012). Dynamic stretching involves stretching using specific movement used in the succeeding exercise; specific stretching uses this principle, however using more specific stretches. Previous research has used stretches that have been designed to mimic the actions within the sprint, in order to investigate the effects specific stretches have on performance (Fletcher and Anness, 2007; Samson et al., 2012). Within previous studies both static and dynamic stretches have been used, yielding significant performance improvements when compared to nonspecific stretches. Within Fletcher and Anness (2007) the specific stretching was compared to the nonspecific stretch protocol using a fifty meter sprint test. The results showed that the specific stretch protocol resulted in significantly faster sprint times than the other stretch protocols. These results have been supported by the findings of Samson et al. (2012), specific stretching protocols yield faster sprint times over twenty meters, when compared to nonspecific stretch protocols. Samson et al. (2012) used both specific dynamic stretches and specific static stretches within the study, both of which increased performance.

Although there is high validity within the results of Samson et al. (2012), the findings of Fletcher and Anness (2007) lack a comparison to a non-specific set of stretches. The results displayed may be due to the detrimental effect static stretching has on sprinting, which has been exhibited in previous research(Fletcher and Jones, 2004;
In order to understand whether specific stretch protocols yield an increase in performance during fifty meter sprints; research which compares specific dynamic stretches against non-specific dynamic stretches must be conducted.

2.4. Methodological Considerations
Lack of warm up has been exhibited in previous research (Stewart et al., 2007; Andrejić et al., 2011); however within the present study it would be deemed unethical to not include a warm up; due to fifty meter sprinting being a maximal task. Without the presence of a warm up there will be an increased level of injury occurrence to all the athletes involved (Rokka et al., 2007 and Soligard et al., 2010). From the results of Goodwin (2002) it can be concluded that in order for warm up to benefit fifty meter sprint speed, three to five minutes of moderate intensity exercise must be performed. Samson et al. (2012) used this protocol in accordance with stretching resulting in significantly faster sprint times. After evaluating the findings of previous literature it is clear that a warm up must be applied within the present study in order to improve performance, but also to prevent the occurrence of injury (Rokka et al., 2007 and Soligard et al., 2010). The warm up should consist of five minutes of moderate intensity exercise, which uses the musculature involved in sprinting, thus a moderate paced run would be best suited.

Within the method of this study, comparison of dynamic stretches specific to sprinting and nonspecific to sprinting will be used. Within Fletcher and Anness (2007) and Samson et al. (2012), stretch protocols were used within the warm up that were designed to mimic the actions within a sprint. Within these studies the stretches chosen to be specific to sprinting were high knee skipping, high knee running, butt-kicks, straight legged skipping and walking high knees. Within the present study a combination of these stretches will be used as they have been stated to mimic the action of sprinting by both Fletcher and Anness (2007), and Samson et al. (2012).
CHAPTER III

METHOD
3. Method

Three different stretch protocols, Sprint Specific Stretching (SSS), Non Specific Dynamic Stretching (NSD) or Non Quadriceps Dynamic Stretching (NQD); were performed in a randomised repeated measures design. Each subject performed a set pulse raising activity, followed by a randomly assigned stretch protocol, and two forty metre sprints.

3.1. Subjects

Participants were recruited from Cardiff Metropolitan University, who were all currently taking part in regular physical activity. Five males (age 20.8 ± 0.9 years, mass 86.3 ± 3.6 kg, height 180.8 ± 4.7 cm) and five females (Age 21 ± 0.7 years, mass 75.3 ± 4.2kg, height 176.3 ± 3.2cm) volunteered for the study. One participant dropped out after one session of the study. All participants had been familiarised with the sprints through their own sports and university curriculum.

The methods and procedures used within the study were approved by the university ethics committee prior to the studies beginning. The protocol procedures and any potential risks were communicated to the participants verbally and via a written participant consent form, which each individual was required to sign prior to participation. A physical activity readiness questionnaire (Par – Q) was required to be filled out by each participant prior to undertaking the study.

Each participant was assigned a designated testing slot each week in order to reduce the effect any additional training may have on the results.

3.2. Equipment

All testing took place inside the National Welsh Athletics Centre (NIAC), at Cardiff Metropolitan University. The track within NIAC, which all testing was performed on, was designed specifically for sprinting, thus reducing the likelihood of slips and possible injury occurrence.

Sprint time was collected using Smartspeed timing gates (FusionSport, Australia) over a fifty metre course. Between twenty and thirty metres on the track, stride
length, stride frequency and ground contact time was collected using the Optojump system, (Microgate, Italy).

3.3. Procedures

3.3.1. Warm Up
Subjects were required to perform the same active warm up followed by a randomly assigned stretch protocol; with each subject completing each stretch protocol once. In order for active warm up to aid fifty metre sprint speed, three to five minutes of moderate intensity exercise must be carried out (Bishop 2003). For this to be achieved, each subject was required to perform five laps of a two hundred metre track, with each lap to be completed in a time no faster than forty seconds and no slower than fifty five seconds. Each warm up was supervised and timed by an investigator.

3.3.2. Stretching Protocols
Immediately after the completion of the warm up, participants were required to perform a randomly assigned stretch protocol. All stretches were performed over a marked twenty metre section of track. Each stretch was performed twice with a jog back recovery in between stretches.
3.3.2.1. Sprint Specific Stretching (SSS)
The SSS warm up consisted of stretches that mimic the actions performed within a sprint (Fletcher and Anness, 2007).

Table 1. The stretching exercises used within the SSS warm up.

<table>
<thead>
<tr>
<th>SSS Stretching Exercises</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Straight Leg Skipping – Straight leg in extension, is abducted in front of body as</td>
</tr>
<tr>
<td>opposite arm swings forward. Once leg reaches a 90 degree angle to the body, leg is</td>
</tr>
<tr>
<td>lowered back to ground underneath the hip, whilst opposite leg swings forward.</td>
</tr>
<tr>
<td>2. Jogging High Knees – Movement consists primarily of jogging however with the main</td>
</tr>
<tr>
<td>emphasis of lifting the knee so the femur is at a 90 degree angle to the body.</td>
</tr>
<tr>
<td>3. Running High Knees – Movement is exactly to that performed in jogging high knees,</td>
</tr>
<tr>
<td>however performed at a faster pace.</td>
</tr>
<tr>
<td>4. Flick Backs – Performed whilst jogging, heals are flicked towards the Gluteus</td>
</tr>
<tr>
<td>Maximus; femur remains in line with the body.</td>
</tr>
<tr>
<td>5. High Bounds – Participant is required to jump vertically off one leg. Whilst airborne</td>
</tr>
<tr>
<td>the opposite legs femur is raised to a 90 degree angle to the body (similar to the</td>
</tr>
<tr>
<td>motion a jogging high knees). A one metre distance should be covered by each jump.</td>
</tr>
</tbody>
</table>
3.3.2. Non-Specific Dynamic Stretching (NSD)
The exercises within the NSD protocol stretch the musculature within the sprint, without mimicking the actions performed within the movement.

Table 2. The stretching exercises used within the NSD warm up.

<table>
<thead>
<tr>
<th>NSD Stretch Exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. High leg raises - Straight leg is lifted</td>
</tr>
<tr>
<td>in front of body as opposite arm swings</td>
</tr>
<tr>
<td>forward. Leg must be raised above a 90</td>
</tr>
<tr>
<td>degree angle to the body. Once raised as</td>
</tr>
<tr>
<td>high as possible, leg is lowered to</td>
</tr>
<tr>
<td>ground underneath the hip, whilst</td>
</tr>
<tr>
<td>opposite leg swings forward.</td>
</tr>
<tr>
<td>2. Walking calf raises – Whilst walking roll</td>
</tr>
<tr>
<td>the foot from the heel up to be on</td>
</tr>
<tr>
<td>toes, plantarflexion of the foot.</td>
</tr>
<tr>
<td>Alternated each step.</td>
</tr>
<tr>
<td>3. Knee Hugs – Femur is raised so it is</td>
</tr>
<tr>
<td>at a 90 degree angle to the body.</td>
</tr>
<tr>
<td>Participant then places arms around the</td>
</tr>
<tr>
<td>knee and pulls the femur towards</td>
</tr>
<tr>
<td>their sternum. Performed alternately</td>
</tr>
<tr>
<td>between legs.</td>
</tr>
<tr>
<td>4. Walking Lunges – Participants take one</td>
</tr>
<tr>
<td>step forward with one leg and lower</td>
</tr>
<tr>
<td>their hips towards the floor by bending</td>
</tr>
<tr>
<td>their knees. The femur in the lead leg</td>
</tr>
<tr>
<td>should be at a 90 degree angle to the body.</td>
</tr>
<tr>
<td>The rear leg should be in a state of</td>
</tr>
<tr>
<td>flexion with a 90 degree angle being</td>
</tr>
<tr>
<td>formed at the knee joint. A push off</td>
</tr>
<tr>
<td>from the front leg is required in order to</td>
</tr>
<tr>
<td>return to a standing position.</td>
</tr>
<tr>
<td>Performed alternately between legs.</td>
</tr>
<tr>
<td>5. Cross leg raises – Similar to high leg</td>
</tr>
<tr>
<td>raises, however the leg is raised across</td>
</tr>
<tr>
<td>the body each time. With each raise, the</td>
</tr>
<tr>
<td>leg should move across the body,</td>
</tr>
<tr>
<td>until it is in line with shoulder on the</td>
</tr>
<tr>
<td>opposite side of the body. Alternate each</td>
</tr>
<tr>
<td>step.</td>
</tr>
</tbody>
</table>
3.3.2.3. Non-Quadriceps Dynamic Stretching (NQD)
These exercises were assigned to this protocol in order to assess the findings of Nelson et al. (2007), who found that when quadriceps were passively stretched prior to sprinting it had a detrimental effect. A stretch protocol with no quadriceps stretching, allowed this study to assess the effect of dynamic stretching of quadriceps prior to sprinting.

Table 3. The stretching exercises used within the NQD warm up.

<table>
<thead>
<tr>
<th>NQD Stretching Exercises</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Walking calf raises – Whilst walking participants roll the foot from the heel up ending on their toes; plantarflexion of the foot. Alternated each step.</td>
</tr>
<tr>
<td>2. Jogging calf raises - Movement is exactly to that performed in walking calf raises, however performed at a faster pace.</td>
</tr>
<tr>
<td>3. Hamstring stretches – Participants take one step forward and lower their trunk to a 90 degree angle to ground. Ensuring both legs remain straight, the hands are extended to the foot of rear leg and extend forward until at a 180 degree angle to the trunk. Once completed participants return to starting position and repeat with opposite leg.</td>
</tr>
<tr>
<td>4. Alternate toe touches – As participant extends one leg forward, using the hand from the opposite side of the body, the touch the toe of the extended leg.</td>
</tr>
<tr>
<td>5. Alternative ‘over the fences’ – Participants raise femur until it is at a 90 degree angle to the body, whilst abducted at the hip joint. The leg is then adducted back to starting position, however whilst being adducted it is raised as if trying to clear an imaginary fence.</td>
</tr>
</tbody>
</table>

All stretches can be seen in Appendix D.

Once all exercises had been completed, subjects performed three repetitions of a fifty metre long stride out at seventy per cent of their maximum velocity with walk back recovery.
3.3.3. **Sprint Protocol**
Following a two minute rest period, participants were required to perform a fifty metre sprint. Electronic Smartspeed Gates (Fusionsport, Australia) were set out at ten metre intervals over the fifty metres, allowing for ten metre split times to be gained. Between twenty and thirty metres, the Optojump system (Microgate, Italy) was placed, allowing for stride frequency, stride length and ground contact time per stride to be collected.

Each participant’s starting position was standing, with their preferred foot on the start line. When ready, participants performed their sprint. Participants were instructed to sprint through all of the Smartspeed gates and to not slow before reaching the final gate. Once completed, a two minute rest period was given to allow recovery time for participants and limit the effect of fatigue.

3.4. **Statistical Analysis**
All data was collected in Microsoft Excel. Statistical analysis of the data was then carried out, mean scores and standard deviations of the two sprints performed by each participant were calculated for each stretch protocol. Sprint time gathered by the Smartspeed gates (Fusionsport, Australia) was measured in seconds (s). From the data gained from the Optojump system (Microgate, Italy), ground contact time, stride frequency and stride length were recorded.

A one way repeated measures analysis of variance (ANOVA) was performed on the data from the Optojump and Smartspeed gates. The data used was a mean average of the two sprints performed after each stretch protocol. For the ten meter split times obtained by the Smartspeed gates a two way repeated measure ANOVA was used. Again, the data used was a mean average of the two sprints performed after each stretch protocol. The significance of all the statistical tests carried out was set at a level of $p < 0.05$. 
CHAPTER IV
RESULTS
4. Results

Figure 1. shows the mean fifty meter sprint time for all three stretch protocols, no differences were observed between the stretch protocols. No differences were observed in stride frequency, stride length and ground contact time; which are shown in Figure 2., Figure 3., and Figure 4. respectively. Ten meter split times of each stretch protocol can be seen in Table 4. The results show that within the first ten meter split, the NQD stretch protocol was significantly faster than the SSS protocol. Between ten and twenty meters, the SSS stretch protocol was significantly faster than both the NQD and NSD stretch protocol. The NSD stretch protocol was significantly faster than the SSS stretch protocol between thirty and forty metres. The SSS stretch protocol was significantly faster than the NQD stretch protocol between forty and fifty metres.

![Figure 1. The mean and standard deviation for mean fifty meter sprint times for the three stretch protocols.](image-url)
Figure 2. The mean and standard deviation for Stride frequency for the three stretch protocols.

Figure 3. The mean and standard deviation for stride length for the three stretch protocols.
Figure 4. The mean and standard deviation for ground contact time for the three stretch protocols.

Table 4. The means and standard deviations of each ten meter split time.

<table>
<thead>
<tr>
<th>Distance (m)</th>
<th>SSS Protocol</th>
<th>NQD Protocol</th>
<th>NSD Protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td>1.798 (±0.174)</td>
<td>1.711 (±0.165)</td>
<td>1.758 (±0.178)</td>
</tr>
<tr>
<td>10-20</td>
<td>1.327 (±0.153)</td>
<td>1.344 (±0.149)</td>
<td>1.355 (±0.144)</td>
</tr>
<tr>
<td>20-30</td>
<td>1.290 (±0.164)</td>
<td>1.288 (±0.161)</td>
<td>1.274 (±0.149)</td>
</tr>
<tr>
<td>30-40</td>
<td>1.292 (±0.173)</td>
<td>1.278 (±0.171)</td>
<td>1.281 (±0.167)</td>
</tr>
<tr>
<td>40-50</td>
<td>1.305 (±0.190)</td>
<td>1.328 (±0.190)</td>
<td>1.316 ± (0.175)</td>
</tr>
</tbody>
</table>

*1 NQD stretch protocol faster than SSS stretch protocol (P<0.05)

*2 SSS stretch protocol faster NQD and NSD stretch protocols (P<0.05)

*3 NSD stretch protocol faster than SSS stretch protocol (P<0.05)

*4 SSS stretch protocol faster than NQD stretch protocol (P<0.05)
The results from the study suggest there are no significant differences in fifty meter sprint time, stride length, stride frequency and ground contact time after performing three different warm up protocols. However there were significant differences observed between the ten metre split time data following the completion of the three different warm up protocols.
CHAPTER V
DISCUSSION
5. Discussion

The results from this study indicate that there are no differences in overall (i.e. fifty metres) sprint performance as a result of undergoing the three stretch protocols. However significant differences were observed when the sprint was divided into ten metre intervals, suggesting that the different stretch protocols employed did influence certain parts of the sprint, if not the overall performance.

There were no differences observed in stride frequency, stride length and ground contact time for the fifty metre sprint following each stretch protocol. Fletcher (2009) developed a deterministic model for sprinting, stride length and stride frequency contributed to the most important factor, angular velocity. Ground contact time directly contributed to stride frequency. Therefore as there was no significant difference observed between these components, it would result in there being no significant differences observed in fifty metre sprint time. It seems that although the stretches within the SSS protocol were more specific to the movement involved in sprinting, there was no effect on fifty metre sprint time.

Despite performance improvements from performing dynamic stretching, the improvements in performance are minimal. An example of this can be seen in Samson et al. (2012), where a 1% performance increase was observed following the completion of different warm ups and stretching prior to sprint performance. Sprinting is a maximal exercise, and involves high velocity contractions, the speed of which can be increased by undergoing dynamic stretching (Fletcher and Anness, 2007), however within Fletcher and Anness (2007) only the difference between static and dynamic stretching were compared. There was no difference in effect when comparing dynamic stretching to stretches designed to mimic the movements in sprinting, suggesting the type or specificity of the dynamic stretch used is irrelevant.

When the sprint times were split into ten metre splits, differences between the stretch protocols were observed. Within the first ten metre split, from the start to ten metres, there were significant differences between the SSS and NQD protocols, with the NQD protocol found to be significantly faster. The start of a sprint race is considered extremely important and can often predict the winner (Bezodis et al.; 2009), therefore these findings are of high importance. The NQD protocol had an absence of quadriceps stretching and the performance increase observed here is possibly due
to the response of the MTU, affecting how it functions. Previous research has stated that sprint performance is enhanced by a stiffer MTU (Fletcher and Jones, 2004; Fletcher and Anness, 2007). Passive stretching decreases the stiffness of the MTU, which in turn decreases the amount of elastic energy that it is able to store (Fletcher and Anness, 2007). When MTU stiffness is decreased, the muscle is not able to store elastic energy within the eccentric phase of contraction associated with sprinting. As a result of this the force transfer from muscle to tendon is not as efficient (Kokkonen et al., 2008) and results in a decreased rate of force production. This may explain the significant differences observed between the SSS and NQD stretch protocols in the first ten metre split. Due to the stretches within NQD protocol, the MTU within the Quadriceps would not have been stretched before the participants performed their sprints, therefore not allowing for the MTU to lose stiffness. Although the stretches within the SSS protocol were dynamic, and have not been found to decrease MTU stiffness (Fletcher and Jones, 2004; Fletcher and Anness, 2007), there is a possibility that the SSS stretches may have done so. As a result the rate of force production and consequently force was higher within the NQD group, explaining the results obtained.

For the rest of the significant differences observed in the ten metre splits, it is less clear as to why they have occurred. Differences were highlighted between all three protocols between ten and twenty metres, with the SSS protocol being fastest. Between thirty and forty metres, NSD is significantly faster than that of the SSS protocol; and between forty and fifty metres SSS is significantly faster than that of the NQD protocol. The Optojump was placed between twenty and thirty metres of the fifty metre sprint course, however for the forty metres of track which was not measured using the Optojump, stride length, stride frequency and ground contact time are all unknown. No differences between the three variables measured by the Optojump were recorded between the twenty and thirty metre split, however due to the results of the present study there may have been differences between the variables. As a result of this and the lack of previous literature investigating ten metre split times, it is very difficult to draw conclusions as to why the significance differences occurred during the splits. However it has been proposed that during the acceleration phase of the sprint, the start, there is more work produced at the knee, thus possibly showing why the NQD protocol yielded a faster sprint time between 0
to 10 metres (Bezodis et al. 2007). However in order to fully understand why these differences occurred further research must be conducted.

Due to limited previous literature comparing specific dynamic stretching to generalised dynamic stretching, the results gained from the study cannot be directly compared to those of any previous work. However there are previous studies (Fletcher and Anness, 2007, Taylor et al., 2009; and Samson et al., 2012) that incorporate aspects of specific dynamic warm up and thus can be used to compared with this study’s findings.

The results of this study are contrasting to those found by Fletcher and Anness (2007). The results from their study show there to be a significant decrease in sprint time when stretches specific to sprinting were performed. The results produced showed a significant decrease of fifty metre sprint time in men of 0.16 seconds (p= 0.001) and a decrease of 0.1 seconds in women (p = 0.003). This study found differences between stretches specific to sprinting and dynamic stretching. However the reasons why these results differ may be due to the type of generalised stretching used within Fletcher and Anness (2007). Within the non-specific stretching protocol, static stretching was used, whereas within the present study dynamic stretching was used. As a result the findings of Fletcher and Anness (2007) cannot be directly compared to those of this study, due to the detrimental effect static stretching has on sprint speed (Winchester et al., 2008; Sim et al., 2009; Andrejić et al., 2011).

Warm up specificity was researched by Samson et al. (2012), who used four different warm up protocols to investigate its effect on sprint and jump performance. Within the study’s protocol, there were two warm up variations, one including three sprint specific exercises that were performed in addition to the general dynamic stretches, and the other only containing the generalised dynamic stretches. Similar to the present study, Samson et al. (2012) reported no significant differences between the stretches designed to mimic the sprint cycle and the non-specific stretches. Although the results from Samson et al. (2012) match those of the present study, they cannot be directly compared due to the differences in the stretch protocols used. Within the present study, sprint specific dynamic stretches were compared to generalised dynamic stretches, therefore avoiding any possible
influence caused by the generalised stretches. This was not accounted for in Samson et al. (2012) as the sprint specific stretches were performed with the generalised stretches; therefore it is unclear whether the results are due to the sprint specific stretches or the generalised stretches.

The fifty metre sprint track was split into ten metre intervals within the current experiment in order to investigate the results of Nelson et al. (2007). Nelson et al. (2007) showed that performing one of three individual static stretch protocols prior to a fifty metre sprint, yielded slower fifty metre times when compared to a non-stretch protocol. The findings of Nelson et al. (2007) were of particular interest as the non-stretch protocol did not stretch one of the prime movers used in sprinting, the quadriceps. Although the NQD stretch protocol’s fifty metre time did not show any differences when analysed against the other protocols, the split times revealed that the NQD protocol was significantly faster over the first ten metres. This may be an important point if the findings of Bezodis et al. (2009) are considered, where four elite coaches identified the start as the most important part of the race. The findings of this study also confirms the findings of Young and Belm (2003), which state stretching prior to an activity that requires high rate of force production, rather than maximal force output, can decrease performance.

5.1. Limitations
Following the conclusion of this research a number of weaknesses appeared within the study. The participants used, even though all of them had previous sprinting experience, were not currently competing in sprinting performance regularly. Although there is no previous literature on this, the effect of the stretch protocols on an athlete regularly competing in sprint performance may be different to the participants used within this study. Within the present study, the participants were required to confirm long term injury history and that they were currently a healthy active sports student; however their immediate physical history was not recorded. The immediate history of the athletes may have affected the results by means such as, dehydration, recent food intake, recent physical activity and minor injuries. Although major injuries would have stopped the participant from competing, minor injuries such as muscle soreness would still allow for the participant to deem themselves fit to perform. Within future research participants would be required to refrain from physical activity twenty four hours before the sprint sessions.
Within the study all sprints were performed with a standing start, with the participant’s preferred foot on the starting line. Within all elite sprint races the athletes start out of starting blocks, Moss (2002) stated that the lower the sprinter starts the better. All participants within the study used a set back- block angle of 70° however front- block angles of 30°, 50° and 70° were used. The results showed sprint starts from a front- block angle of 30°, were 24% and 5% faster than the 70° and 50° angled front- blocks respectively. By starting lower the ankle is in a state of dorsiflexion, which in turn causes pre stretching of the gastrocnemius and Achilles tendon, resulting in a higher rate of force production at the starting gun (Moss, 2002).

Due to this study not using starting blocks, the ecological validity of the results are lowered as starting blocks are used in elite sprint competition. In order for the results gained from this study to be applied to elite sprint competition, a study which employs a similar if not identical experimental design, with the use of starting blocks, must be conducted.

The Optojump system was only placed between twenty and thirty metres of the fifty metre sprint track. As a result the stride frequency, stride length and ground contact time of each sprint were only recorded for this ten metre section of the track. Within the results gained from the study, ten metre split time data revealed significant differences between at least two stretch protocols over all of the other split times of the forty metre of sprint track. Due to the Optojump system not being placed in these ten metre splits, where the significances occurred, the influence of stride length, stride frequency and ground contact time on these results are unknown. Within the present study the Optojump was placed between twenty and thirty metres as it was proposed that the end of the acceleration phase and start of the transition phase would be able to be measured. In future research in order to gain an understanding of why these significant differences occurred, the Optojump system needs to be placed over all ten metre splits.

5.2. Conclusion

The mean fifty metre sprint time results suggest that undergoing a dynamic sprint specific stretch protocol prior to sprinting does not increase performance.

Although fifty metre sprint time was not found to be decreased, the sprint specific stretch protocol did yield significantly faster ten metre split times between ten and
twenty metres and between forty and fifty metres. Due to the positioning of the Optojump system, it is unclear as to why these results occurred, as stride length, stride frequency and ground contact time were unable to be recorded over these distances.

Not stretching the quadriceps prior to sprinting resulted in significantly faster sprint time over the first ten metre split, adding to the existing literature that stretching the quadriceps prior to performance can lead to slower rate of force production. This finding in particular may yield greater sprint performance over fifty metres when the variables used to assess sprint performance are measured over the entire distance of a sprint race.
CHAPTER VI

REFERENCES


Carvalho, FLP., Carvalho, MCGA., Simão, R., Gomes, TM., Costa, PB., Neto, LB., Carvalho, RLP., and Dantas, EHM. (2012). Acute effects of a warm-up including active, passive, and dynamic stretching on vertical jump performance. *Journal of Strength and Conditioning Research, 26* (9), 2447 – 2452.


CHAPTER VII

APPENDICES
APPENDIX A

PARTICIPANT CONSENT FORM
Participant Consent Form

Purpose:
The purpose of this study is to develop an understanding of the influence of stretching on sprint performance.

Procedure:
If you agree to be in this study, you will be asked to do the following:

1. Complete a Par – Q health questionnaire to ensure you are in appropriate physical health to participate without the risk of injury.
2. Attend three sessions in which you will be required to carry out a set active warm up, followed by a randomly assigned stretch protocol, which will differ each session. Following a two minute break, participants will be required to perform two maximal fifty meter sprints with a two minute rest in between.

The total time required to complete the study should be approximately 120 minutes.

Benefits/Risks to Participant:
Participants will be disclosed a set of results on request, thus able to see which type of stretching is best for sprint speed and performance. This in turn may benefit own individual performance in the future. Risks include any injuries or discomfort you may experience whilst performing the sprint.

Voluntary Nature of the Study/Confidentiality:
Your participation in this study is entirely voluntary and you may refuse to complete the study at any point during the experiment, or refuse to complete any session which you are uncomfortable or under stress. You may also stop at any time and ask the researcher any questions you may have. Your name will never be connected to your own individual results or to your answers on the health questionnaires; instead, a number will be used for identification purposes. However each participant may request a set of their own individual results once the study has been concluded. Information that would make it possible to identify you will never be presented in the study’s findings. The data will be accessible only to those working on the project.

Contacts and Questions:
At this time you may ask any questions you may have regarding this study. If you have questions, you may contact Zach Kinnaird on st10001454@outlook.uwic.ac.uk.

Statement of Consent:
I have read the above information. I have asked any questions I had regarding the experimental procedure and they have been answered to my satisfaction. I consent to participate in this study.

Name of Participant_________________________________________Date: __________
(please print)

Signature of Participant __________________________________________

Thanks for your participation!

Figure 5. Participant consent form.
APPENDIX B

PAR - Q
APPENDIX C

OPTOJUMP AND ELECTRONIC
SMARTSPEED GATES SETUP
Figure 7. Optojump and Electronic Smartspeed Gates set up.
APPENDIX D

STRETCH PROTOCOL PHOTOGRAPHS
Straight leg skipping

Walking high knees

Running high knees
Figure 8. Sprint Specific Stretching (SSS) photographs
Walking calf raises

Jogging calf raises

Straight legged hamstring stretch
Alternate toe touches

Alternate ‘over the fences’

Figure 9. Non-Quadriceps Dynamic Stretching (NQD) photographs
Cross body leg raises

Walking calf raises

Knee hugs
Walking lunges

Cross body leg raises

**Figure 10.** Non-Specific Dynamic Stretching (NSD) photographs