To Investigate the Effects of Static Stretching and Dynamic Stretching on Power and Agility Performance in University Students

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Abstract. Warming up before the start of any physical activity has been a common practice for many decades. It serves to prepare an athlete physically and mentally for optimal performance. Stretching is one of the main components of a warm up, and it is usually done in the form of static stretching or dynamic stretching. Static stretching has been demonstrated to impair performance, while dynamic stretching has been suggested to enhance performance. For this study, it was hypothesized that dynamic stretching would be more effective in enhancing power and agility performance in university students. 16 participants who trains or exercise at least twice per week volunteered for this study. A within-subject, randomized crossover design was employed, and participants had to undergo two intervention protocols – static stretching (SS) and dynamic stretching (DS), on two separate sessions. After each stretching protocol, participants had to perform a standing broad jump and 4x10m shuttle run test with three attempts each. Only the best attempt for each test was recorded for data analysis. Results demonstrated a significant difference ($p \leq 0.001$) between the mean for standing broad jump between SS and DS, with DS having a higher mean (204.4 ± 39.11) than SS (196.0 ± 33.69). A significant difference ($p = 0.017$) was also demonstrated between the mean for the shuttle run test, with DS (11.11 ± 1.35) performing better than SS (11.33 ± 1.44).

Keywords: Static Stretching, Dynamic Stretching, Power Performance & Agility Performance

1 Introduction

1.1 Background

Warming up prior to any physical activity has been widely practiced for many decades, with the intention of preparing an athlete for optimal performance (Young & Behm, 2002). It typically comprises 3 main components: 1) a

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submaximal aerobic activity such as jogging or cycling; 2) stretching exercises for specific muscle groups and; 3) rehearsing of the sport-specific movement or skills (Young & Behm, 2002; Behm & Chaouachi, 2011).

There are a few different types of stretches that are performed, including static stretching (SS), dynamic stretching (DS), proprioceptive neuromuscular facilitation (Young & Behm, 2002). Static stretching is one of the most commonly performed type of stretches for many years. It involves a controlled lengthening of a muscle, whereby the end range of motion (ROM) is held in place for a specific amount of time. Static stretching has been proven to be effective in increasing ROM (Haddad et al., 2014). Furthermore, other proposed benefits of SS include a reduction in risk of injury (Cramer et al., 2004), decreasing muscle soreness (High, Howley & Franks, 1989) and enhanced athletic performance (Sullivan et al., 2009). One possible explanation for the improvement in physical performance is due to muscle's improved ability to stretch, and a lowered resistance of a compliant muscle (Young, 2007). Nevertheless, a few studies demonstrated that SS does not lower the risk of injury (Herbert & Gabriel, 2002; Small et al., 2008).

On the other hand, DS involves movement from a neutral position to its end ROM, where muscle length is elongated, and then returning to its original position. These stretches are performed in a smooth and controlled manner, and repeated for a specific number of repetitions (O'Sullivan, Murray & Sainsbury, 2009). Numerous studies have concluded the positive effects of DS, such as enhancing athletic performance in the areas of agility, explosiveness and vertical jump height (Haddad et al., 2014). It was suggested that DS improves performance by increasing the excitability of motor units and improved kinesthetic sense. Thus, it improves proprioception and pre-activation (Bishop & Middleton, 2013).

1.2 Purpose and Rationale

The purpose of this study is to broaden the current literature regarding the topic of SS and DS on performance. Most of the existing studies used performance

measures such as vertical jump or a variety of agility tests including the 505 test and Illinois agility test. These measures are certainly relevant in certain sports. However, there is a lack of studies that uses a broad jump or 10-meter shuttle run to measure power and agility performance respectively. These two tests are relevant because they are components of the International Physical Fitness Test, as well as Singapore's National Physical Fitness Award (NAPFA). As NAPFA test is compulsory for primary 2, 4 & 6 students, secondary 2,4 & 5 students and junior college 2 students in Singapore, this study may provide valuable insights to help them improve their performance.

1.3 Aim and hypothesis

The specific aim of this study is to evaluate whether SS or DS is more effective in enhancing power and agility performance. Power and agility are important components of sport performance in several types of sports. Furthermore, they are also commonly evaluated during recruitment of new athletes, as well as general fitness tests, such as the International Physical

Fitness test or the NAPFA test. It is hypothesized that DS would be more effective than SS in improving power and agility performance.

2 Literature Review

The literature on the effects of static and dynamic stretching on sport performance is very well-studied. This section will discuss several past research regarding this topic and how it is relevant to this current study.

A systematic review of the acute effects of static and dynamic stretching on performance done by Behm & Chaouachi (2011) found that there are a number of studies whose results suggests that SS does not impair performance and supported with possible reasons. It was also suggested that physical activities with relatively longer ground contact times like jumping may not be significantly impaired by SS. Static stretching was once thought to improve performance for various reasons. The increase in performance was attributed to the improved ability of a muscle to stretch, as well as decreasing the stiffness of the muscle. Overall, this systematic review found that the majority of studies

are in agreement that SS does actually impair performance. Only a small number of studies reported no significant differences or improved performance.

Another research done by Gelder & Bartz titled "the effect of acute stretching on agility performance" (2011) was one of the few studies that examined the effects of stretching on agility. Many studies focused on the impact of stretching on athletic components such as force, power and sprinting speed. There is a lack of literature regarding how agility is affected by different stretching techniques. The participants in this study were assigned into three groups – static stretching, dynamic stretching and no stretching. They were tasked to perform the 505-agility test to determine which stretching technique resulted in a better performance. The results showed that the dynamic stretching group performed significantly better than the static stretching and the control group. However, a between-subject design was used for this study. Thus, it was unclear whether static or dynamic stretching would be better for individual performance.

A study titled "effects of dynamic and static stretching on vertical jump performance and electromyographic activity" done by Hough, Ross & Howatson (2009) investigated how static stretching and dynamic stretching affected vertical jump performance, as well as using electromyography (EMG) to assess muscle activity following each stretch protocol. This research employed a within-subject, randomized crossover study design where participants had to undergo three different protocols on different sessions – static stretching, dynamic stretching and no stretching. It was established that static stretching led to a significant decrease in jump performance as compared to the dynamic stretching and control group. EMG activity was also reported to have a significant increase after dynamic stretching. Overall, this study coincides with many other research that demonstrated how jump performance is impaired by static stretching.

Another study titled "the use of static stretching in warm-up for training and competition" authored by Young (2007) highlighted the common limitations that many studies have. The two important points mentioned were stretch duration and stretch intensity. For instance, Young noted that a particular study involved a protocol using stretches of 30-minutes duration. This is an important factor because some studies have suggested that stretches of longer duration may result in a larger magnitude of performance impairment than a shorter duration. Often, most studies that demonstrated a negative effect of static stretching tend to use at least 2 minutes of stretch for each muscle group. Thus, stretching protocols of such durations are not representative of a real-world training setting.

Stretch intensity is another important point to consider when implementing protocols. In some studies, this were usually not well described and controlled. Examples of instructions given were to stretch until the point of "pain threshold", until "pain was received" and "just before discomfort". There are also studies where participants were not given specific instructions for their stretches. It was pointed out that stretch intensity should be taken into account, because it can play a significant role in performance. A study reported that stretching of a muscle with 10% less elongation as compared to the "point just before pain" did not result in impaired power production.

Overall, these literature review highlights that despite the consensus that DS is more effective in improving performance, there are still some studies which disagree with the statement. Furthermore, it is important that stretching protocols are designed in a way that is more applicable to athletes in a real setting, thus increasing the practicality of the study.

3 Methodology

3.1 Recruitment

A total of 16 participants (Height = 166.44cm ± 13.62, Weight = 64.3kg ± 14.9; Mean ± SD) volunteered for this study. Participants would only be recruited if they were 21-27 years old and were free from any injuries within the past 6 months. In addition, they must also be physically active, and exercise or take part in any form of physical activity at least twice per week. Participants who

did not fulfill any of the aforementioned criteria were excluded from the study. This study was approved by the Institutional Review Board of Nanyang Technological University. All participants have read and signed an informed consent document.

3.2 Study Design

This study was performed using a randomized crossover, within-subject study design. There were two independent conditions for this study; SS and DS, thus participants had to attend two separate sessions. Each session was separated by least 48 hours. A coin toss was used to determined which condition each participant will be assigned to for their first session. Following each protocol intervention, participants would undergo two performance measures; standing broad jump test and a 4x10m shuttle run test. These tests were used to access power and agility performance respectively. The order of performance testing was also conducted in a randomized order for each participant. However, the order of testing for an individual participant remained consistent across both sessions. Similarly, a coin tossed was used to determine the order of performance tests. The entire procedure was conducted in an indoor sports facility to minimise any effects of wind resistance or bad weather conditions.

3.3 Methods

The entire study procedures were explained to each participant for familiarization purposes. Participants would start each session by jogging at a self-selected pace for 3 minutes. After jogging, they were told to rest for 3 minutes. They would then proceed to perform their stretching protocol that they have been assigned for that session. A demonstration for each stretch was shown to each participant so that they would be able to perform them correctly. Table 1 and table 2 shows the types of SS and DS stretches respectively and the duration to be performed. Both stretching protocols were adapted from Gelder & Bartz (2011) study.

3.1 Static Stretching

The stretches used in this protocol were constructed to be as similar as possible to conventional stretches that many athletes use prior to physical activity. The muscles that are emphasized include the main locomotive muscle groups such as the hip flexors, hip abductors and adductors, gluteal, quadriceps, hamstrings and gastrocnemius. It also comprises some emphasis on the erector spinae, pectorals, abdominals and obliques. All stretches are done in sets of 30 seconds, because it is representative of a real-world training setting (Gelder & Bartz, 2011). There have been studies performed where stretches were held for more than 30 seconds, and researchers have found that it does not provide additional increases in ROM (Bandy, Irion & Briggler, 1997). In addition, participants were told to stretch each muscle at the point just before discomfort. Table 1 shows the order of static stretches performed.

3.2 Dynamic Stretching

The DS protocol was designed to closely replicate common dynamic stretching techniques used by many athletes. It comprises a mixture of mobility drills, movements within an active ROM and simple plyometrics. A huge emphasis is placed on the muscles of the lower limbs, whilst targeting the other upper body muscles with active upper-limb movements. Table 2 shows the order and repetitions of dynamic stretches of which they were performed.

Table 1 Static stretch protocol

Stretch name	Muscle emphasis	Time (s)	Sets
Butterfly	Adductors	30	1
Sit and reach	Spinal erectors and hamstrings	30	1
Floor back extension	Abdominals	30	1
Lateral bend	Obliques	30	2 (1 per side)
Wall pec	Pectoral groups	30	2 (1 per side)

Abductor	Iliotibial band	30	2 (1 per leg)
Standing 1-leg quadriceps	Quadriceps	30	2 (1 per leg)
Seated 1-leg hamstring	Hamstrings	30	2 (1 per leg)
Calf stretch	Gastrocnemius and soleus	30	2 (1 per leg)

Table 2 Dynamic stretch protocol

Stretch name	Muscle emphasis	Repetitions
Supine knee rocking	Pelvic, spinal mobility	20
Prone scorpion	Quadriceps, gluteus maximus, obliques	10
Hand walkout	Erector spinae, gastrocnemius, soleus	5
Prisoner squats	Quadriceps, hamstrings, rhomboids	10
Lunge with twist	Quadriceps, hamstrings, obliques	5 per side
High knees	Quadriceps, gastrocnemius, soleus	20
Heel kicks	Hamstrings, gluteus maximus, gastrocnemius, soleus	20
Leg swing	Hamstrings, iliopsoas, gluteus maximus	10 per side
Box drill hops (counter and clockwise)	Gastrocnemius, soleus	10 CW/CCW
Single leg hops (back and forth)	Gastrocnemius, soleus	10
Single leg hops (side to side)	Gastrocnemius, soleus	10
Carioca	Gastrocnemius, soleus, adductors, abductors	4 x Half of a basketball court

Upon completion of the entire stretching procedures, participants rested for 2 minutes before the commencement of the performance measures tests.

3.4 Performance measure tests

3.4.1 Standing broad jump

Participants started by standing behind a starting line, and were told to jump with their maximum effort. No practice trials were allowed to minimise any learning effects. A total of three attempts were given to each participant, with a 1-minute rest between each attempt. A measuring tape was used to measure the jump distance. The best performance was used for data analysis. After three attempts were completed, participants were rested for 2 minutes before performing the 4x10m shuttle run test.

3.4.2 4x10m shuttle run

Prior to the test, the starting line and the 10-m line was established and made clear to each participant. This was achieved using a cone and masking tape. Participants had to start behind the starting line, and upon giving the signal "3, 2, 1, go!", the timer would start and they had to perform the test with maximum effort. For the first three laps of 10-m, participants were required to touch the line with their preferred hand before turning around. Similarly, a total of three attempts were given, with a 1-minute rest between each attempt. Only the best timing was used for data analysis. After the test was completed, a 2-minute rest was given before performing the standing broad jump test.

4. Results

Statistical analysis of the data was performed using JASP (Version 0.13.1). A paired samples T-test was used to determine statistical significance ($p \leq 0.05$).

Table 3 represents the descriptive statistics of each performance measure tests for both SS and DS protocols.

Table 3 Means ± SD of performance measure tests

Condition	Sample size N	Mean ± SD Standing broad jump (cm)	4x10m shuttle run (s)
Static stretching	16	196.0 ± 33.689	11.34 ± 1.443
Dynamic stretching	16	204.4 ± 39.108	11.11 ± 1.349

There was a significant difference in the mean of the standing broad jump distance between SS and DS conditions ($p \leq 0.001$). Participants were able to jump further (204.4cm ± 39.11, mean ± SD) for the standing broad jump test when they performed DS as compared to SS (196.0cm ± 33.69). Similarly, there was also a significant difference in the mean of the 4x10m shuttle run times between SS and DS conditions ($p = 0.017$). Participants performed significantly faster (11.11s ± 1.35) when DS was performed as compared to SS (11.34s ± 1.44).

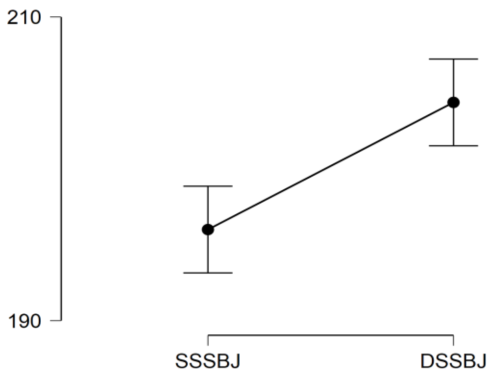

Figure 1 Standard error bar for standing broad jump. SSSBJ – static stretching standing broad jump; DSSBJ – dynamic stretching standing broad jump

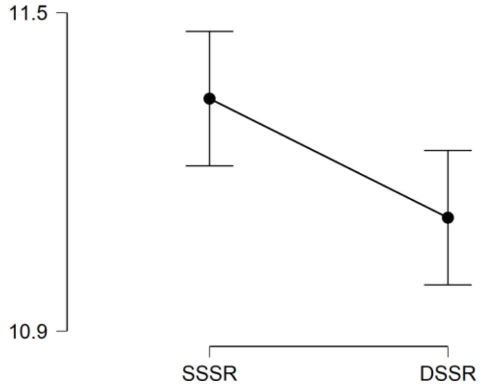

Figure 2 Standard error bar for 4x10m shuttle. SSSR – static stretching shuttle run; DSSR – dynamic stretching shuttle run

5. Discussions and conclusions

5.1 Discussions

The results of this study support the hypothesis that DS is more effective in enhancing power and agility performance than SS. The data has revealed that there was a significant difference in both standing broad jump and shuttle run performance, with DS having higher means than SS. Based on the current literature, there are many studies that are equivocal in concluding that SS is detrimental for power and agility performance. A study done by Winchester, Nelson &

Kokkonen (2009) found that even a single set of SS performed for 30 seconds was sufficient to reduce maximal voluntary strength. In another study, counter-movement jump performance was found to be decreased following a session of SS that lasted for 5 minutes, but returned to baseline levels after 15 minutes (Bradley, Olsen & Portas, 2007).

With respect to agility performance, the results of this study coincide with various other studies as well. Despite using different agility tests in all of these studies, it was concluded that DS was beneficial for improving performance (Khorasani, Sahebozamani, Tabrizi & Yusof, 2010; Little & Williams, 2005; McMillan, Moore, Hatler & Taylor, 2006). There are several proposed reasons as to why SS may cause a reduction in sport performance. One reason is that SS reduces the stiffness of the musculotendinous unit, thus negatively affecting the amount of elastic energy that can be stored and reused (Haddad et al. 2014). In addition, the slack in the musculotendinous unit as a result of SS can delay the transmission of forces through tendons. This prevents maximal storage and decreases the efficiency of utilizing elastic energy during the stretch shortening cycle (Nelson, Driscoll, Landin, Young & Schexnayder, 2005). Another possible reason is that SS increases the tendon compliance, thus lowering maximal force production (Power, Behm, Cahill, Carroll & Young, 2004).

There seems to be a general consensus in the literature that DS is more effective at enhancing power and agility performance. Researchers have theorized possible mechanisms for this improvement. Firstly, DS improves performance as a result of increasing the muscle and body temperature prior to physical activity (Fletcher & Jones, 2004). An increased in muscle temperature has been shown to provide a number of benefits. It reduces stiffness of muscles, increases force production and anaerobic power, and lowers concentration of lactate in blood and muscles. It also increases the rate of glycogenesis, glycolysis, and stimulates the degradation of high-energy phosphate (Gelder & Bartz, 2011). Next, DS may have a post-activation potentiation effect on the muscles due to contractions of the antagonist, stimulation of the nervous system, and reduced inhibition of the antagonist muscles (Behm & Chaouachi, 2011). Another suggestion was that DS increases the rate which cross-bridge attachments can be formed. This increases the number of cross-bridges allowed to be formed, hence resulting in enhanced force production (Behm & Chaouachi, 2011).

5.2 Limitations and future research

One limitation of this study is that the participants were of different training background and experience. It is possible that highly trained athletes, or athletes who participate mainly in power and/or agility dominant sports are more resistant to the differences that may arise as a result of SS or DS, or vice-versa. Thus, future research could look into recruiting participants who are very similar in training experience and background.

5.3 Conclusion

In summary, dynamic stretching is more effective in enhancing power and agility performance. Athletes who participate in sports where power and agility are key components of athletic performance, or those who are looking to improve their results in a physical performance test should look to incorporate dynamic stretching instead of static stretching during their warm-up.

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