THE EFFECTS OF DYNAMIC AND STATIC STRETCHING PROTOCOLS ON POWER, AGILITY AND FLEXIBILITY IN ELITE WRESTLERS

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MURAT ÇELEBİ

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____

Prof. Dr. Meliha ALTUNIŞIK
Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Doctor of Philosophy.

____

Prof. Dr. Settar KOÇAK
Head of Department

This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Doctor of Philosophy.

____

Assoc. Prof. Dr. Sadettin KİRAZCI
Supervisor

Examining Committee Members

Prof. Dr. Settar KOÇAK	(METU, PES)	____________________
Assoc. Prof. Dr. Sadettin KİRAZCI	(METU, PES)	____________________
Prof. Dr. Ayşe KİN İŞLER	(HÜ, SBF)	____________________
Assoc. Prof. Dr. Haluk KOÇ	(GÜ, BESYO)	____________________
Assist. Prof. Dr. Irmak H. ALTUNSÖZ	(METU, PES)	____________________

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Name, Last Name : Murat ÇELEBİ

Signature :

ABSTRACT

THE EFFECTS OF DYNAMIC AND STATIC STRETCHING PROTOCOLS ON POWER, AGILITY AND FLEXIBILITY IN ELITE WRESTLERS

ÇELEBİ, Murat
Ph.D., Department of Physical Education & Sports
Supervisor: Assoc. Prof. Dr. Sadettin KİRAZCI

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The purpose of this study was to investigate the effects of static stretching (SS), dynamic stretching (DS) and no stretching (NS) protocols on power, agility and flexibility in competitive wrestlers. 34 competitive male athletes were recruited for Standing Long Jump, T-Drill and Sit and Reach Test to test power, agility and flexibility of the subjects respectively. The participants performed one of the tests on each day.

After the analysis of repeated measures of ANOVA, the results indicated that the measurements did not show significant power improvements after the stretching types, $F(2, 66) = .376$, $p > 0.05$. However, statistically significant agility scores were found $F(1.559, 51.463) = 5.88$, $p < 0.05$). The score were NS (M = 10.206, SD = .474), DS (*M* = 10.094, *SD* = .547) and SS (*M* = 10.335, *SD* = .585). There was also significant flexibility scores after the stretching,, $F(1.83, 60.39) = 9.11$, $p<0.05$). The scores were NS (*M* = 34.36, *SD* = 6.26), DS (M = 34.84, *SD* = 6.17) and SS (*M* = 34.74, *SD* = 6.39).

According to this study, dynamic stretching has a positive effect in agility and flexibility in wrestlers. Static stretching has also a meaningful effect in terms of flexibility outcomes. Coaches and athletes would consider dynamic stretching before power, agility and flexibility related exercises instead of static stretching.

Keywords: Dynamic stretching, static stretching, power, agility, flexibility

ÖZ

ELİT GÜREŞÇİLERDE DİNAMİK VE STATİK GERME PROTOKOLLERİNİN GÜÇ, ÇEVİKLİK VE ESNEKLİK ÜZERİNE ETKİLERİ

ÇELEBİ, Murat

Doktora, Beden Eğitimi ve Spor Bölümü

Tez Yöneticisi: Doç. Dr. Sadettin Kirazcı

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Bu çalışmanın amacı elit güreşçilerde dinamik ve statik germe protokollerinin güç, çeviklik ve esneklik üzerinde ki etkilerinin araştırılmasıdır. 34 elit müsabık erkek güreşçi bu çalışmaya katılarak dinamik germe ve statik germe protokollerini uyguladılar. Katılımcılar her gün bir tanesi yapılan bu germe protokollerinden sonra Durarak uzun atlama, T-Drill ve Otur ve uzan test ölçümlerini gerçekleştirdiler.

Sonuçlara göre Dinamik Germe Protokolü (*M* = 15.371.4, *SD* = 945.09), Statik Germe Protokolü (*M* = 15.370.3, *SD* = 961.2), *F* (2, 66) = .376, p > 0.05) ve Germe Yapılmayan Protokol (*M* = 15.359.4, *SD* = 934.2) uygulamaları sonrasında katılımların güç değerlerinde anlamlı bir artış görülmedi. Anlamlı bir artış olmamasına rağmen, Dinamik Germe Protokolünden sonra katılımcıların güç değerlerinde azda olsa bir artış gözlenmiştir. Bunun aksine, Dinamik Germe Protokolü (*M* = 10.094, *SD* = .547), Statik Germe Protokolü (*M* = 10.335, *SD* = .585), *F*(1.559, 51.463) = 5.88, *p* <0.05) ve Germe yapılmayan Protokol (M = 10.206, SD = .474)) sonrasında katılımcıların çeviklik değerlerinde anlamlı bir gelişme bulundu. Yukarda ki anlamlı gelişmeye ek olarak, germe protokollerinden sonra katılımcıların esneklik değerlerinde de (Dinamik Germe Protokolü (M = 34.84, $SD = 6.17$), Statik Germe Protokolü ($M = 34.74$, $SD = 6.39$), $F(1.83, 60.39) = 9.11$, $p<0.05$) ve Germe Yapılmayan Protokol ($M = 34.36$, $SD = 6.26$), anlamlı artışlar bulundu. Sonuç olarak, antrenörler ve sporcular güç, çeviklik ve esneklik egzersizlerinden önce Dinamik Germe Protokolünü tercih edebilirler.

Anahtar Kelimeler: Dinamik germe, statik germe, güç, çeviklik, esneklik

To My Love Kids

My Mother

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CHAPTER 1

INTRODUCTION

Wrestling is frequently acknowledged as the oldest of all sports. It is one of the few original events in the ancient Olympics and its heritage can be traced across cultures, from pictures alongside Egyptian hieroglyphics to the murals in Chinese tombs (Kent, 1981). Wrestling has many performance dynamics that determine the successful application of a technique or winning a competition. Power, agility and flexibility are some of those important main aspects of modern Olympic wrestling like reaction time and endurance since they are crucial to be successful in wrestling workouts and competitions.

Stretching is generally preferred by wrestlers to increase flexibility, develop athletic condition, and reduce injury risks (Rosenbaum & Henning, 1995). There are differences in performing stretching activities from sports to sports and even from practice to practice. Coaches and researchers are willing to know which type of stretching exercise is best for optimal athletic performance in warm-up before heavy workouts. There are many stretching types in the athletic word today such as dynamic stretching, static stretching, ballistic stretching, active stretching, passive stretching, isometric stretching and PNF stretching. There are various scientific studies that recommend different stretching procedures for the same purpose. Some researchers revealed that stretching caused decrease in performance (Siatras, Papadopoulos, Mameletzi, Vasilios & Kellis, 2003; Kistler, Walsh, Horn & Cox, 2010; Yamaguchi, Ishii & Yamanaka, 2006). On the contrary, quite a few studies claimed no negative influence on athletic or competitive outcomes (Dalrymple, Davis, Dwyer & Moir, 2010; Beedle, Rytter, Healy & Ward, 2008), whereas some researchers have shown that stretching affects performance positively (Curry, Chengkalath, Crouch, Romance & Manns, 2009; Vetter, 2007; Bacurau, Monteiro, Ugrinowitsch, Tricoli, Cabral, & Aoki, 2009). Some did not find any significant difference between static, dynamic and no stretching protocols after performing jumps (Dalrymple et al., 2010).

For long years, static stretching (SS) was accepted as an important routine of a warm-up and is applied by moving a body part towards the limits of Range of Motion and keeping it stable for 15–60 sec. (Young & Behm, 2002). Moreover, SS has a slow, deliberate movement in its Range of Motion that can be sustained for a period of 10 to 30 seconds to train the neuromuscular responses of the sensory receptors within the muscle, usually explained as the closest end prior to the beginning of pain (Kaminsky, et al., 2006). SS was favored as a useful practice to enhance Range of Motion (ROM) of a joint (Power, Behm, Cahill, Carroll & Young, 2004). It is offered to avoid injury through improving the Range of Motion of a joint or a set of joints (Hendrick, 2004). It is well presented that injury threat might be lowered by the protocol of a well-structured warm-up before intense physical activity (Alter, 2004). In terms of reducing and preventing the injury, some studies offered SS in the beginning of a physical activity (Safran, Seaber & Garrett, 1989). Also, decline in muscle pain and improved performance were also recorded as the benefits of SS (High, Howley & Franks, 1989, Young & Behm, 2002). When applied properly, the risk of injury caused by the stretch is decreased (Baechle & Earle, 2000). The literature shows that SS improves Range of Motion (ROM) and could as well reduce stiffness, for yet shorter stretch times (5–30 s) (Bacurau, 2009). Because of that, stretching and warm-up routines may have ability to change the outcomes of any competitive athletic performance and prevent the possible future injuries.

Quite a few literatures reveal negative findings of SS in terms of performance, such as, Kistler, Walsh, Horn, & Cox (2010) states that it appears detrimental to involve SS in beginning of the physical activity for short distance runners up to 100 m. distances. Furthermore, Costa, Santos, Prestes, Silva & Knackfuss (2009) concluded that the SS protocol produced detrimental effect on the maximal strength in the evaluated athletes. Similarly, Yamaguchi, Ishii & Yamanaka (2006) recommend that fairly extensive SS lower power performance. As for the endurance athletes, Wolfe, Brown, Coburn, Kersey & Bottaro (2011) suggested that elite athletes might eliminate SS directly prior to intermediate intensity cycling since it diminish acute cycling economy. Also for running, Damasceno, Duarte, Pasqua, Lima-& Macintosh (2014) found that SS damaged neuromuscular function, which caused a slow start during a 3-km running time-trial.

Despite the studies showing negative effects of static stretching, some researches show none or disappearing detrimental effect of SS on performances. Mizuno, Matsumoto & Umemura (2014) recommended that the negative effects of SS disappeared shortly following static stretching. Egan, Cramer, Massey & Marek (2006) revealed no effect on torque and mean power output after static stretching. They stated in elite athletes SS did not create any negative effect on power during maximal muscle contractions. Moreover, Cramer, Housh, Johnson, Weir, Beck & Coburn (2007) presented that SS did not change maximal torque and power production, and it also did not alter muscle activation. Considering the consequences of static stretching, some researchers have stated a decrease in mean running speed (Siatras, 2003) or no change at all (Little & Williams, 2006) after applying the SS protocol.

Some studies looked into the reasons of the negative sides of the SS and these negative effects of SS are attributed to neural and mechanical factors (Avela, Finni, Liikavainio, Niemela, & Komi, 2004). Cramer et al., (2005) found that SS decreases the motor unit activation during maximal voluntary contraction. According to the data, SS changes muscle-tendon units (MTU) length and stiffness (Kato, Kanehisa, Fukunaga, & Kawakami, 2010). We can conclude that this change in MTU length, stiffness and muscle activation could affect reaction and movement times (Behm, Bambury, Cahill, & Power, 2004). In addition, significant decrease were found in strength (Fowles, Sale, & MacDougall, 2000), a lowered jumping outcome (Cornwell, Nelson, Heise, & Sidaway,

2001) and decreased sprint times (Fletcher & Annes, 2007). Due to the above scientific studies increasing the concerns regarding the potential performance impairments of SS, there is a growing tendency towards dynamic stretching (DS).

In the literature, various theories attempt to make clear the reasons of the negative effects of SS on power performances. The stiffness was one of the reasons of the decline in results of the tests. Cornwell, Nelson & Sidaway (2002) researched the acute effects of stretching on the active stiffness during maximal jumps and they found SS routines have detrimental effect on the power outcomes. In a similar study performed on force, Young & Behm (2003) investigated the effect of SS on explosive force productions and jumping performances and the researchers stated that SS protocol showed a lowering impact on explosive force and jumping performance. Gonçalves et al., (2013) also investigated the acute effects of SS on force performances. Similar to the results of elite athletes following static stretching, sedentary people also responded in the same way with similar detrimental outcomes after the SS routines.

Durations of the stretching are also important for performance. Siatras and his colleagues (2008) looked into acute effects of various SS periods on peak torque production. They suggested that SS movements with over 30 seconds exertions must not be performed prior to athletic events entailing highest strength. Robbins & Scheuermann (2008) investigated the connection in different durations and volumes of acute SS on jumping performance. They did not recommend stretches over 6 sets or 90 seconds ahead of power events like jumps or sprints. Costa et al., (2009) also studied the results of various lengths of SS on dynamic balance. They presented that the duration for 45 seconds for keeping the stretch did not influence balance negatively. However, keeping the stretch for 15-seconds might advance balance outcome. According to these studies, the results recommended to apply stretches with brief periods if the balance is the purpose of the training. Another example study looked at the effects of 15-second duration of the stretching on performance outcomes was done by Knudson, Bennett, Corn, Leick & Smith (2001) and found improved jumping velocity in 35% of the participants after 15-second duration of the stretching protocol. Furthermore, American College of Sports Medicine (ACSM) advises keeping the stretching for about 15 to 30 sec. in its guidelines (ACSM, 2005).

Dynamic Stretching (DS) as a warm-up protocol is becoming more popular day by day. It has been documented that DS is more beneficial for performance (Howley, 2003). The dynamic stretches have the movement patterns used in a sport, for that reason, it can improve athletic coordination and provide sport-specific skill rehearsal (Fletcher, 2004). DS protocol involves the performance of movements ranging from low to high intensity and intended to raise body temperature, improve motor unit responsiveness, advance kinesthetic alertness, and increase ranges of motion (Faigenbaum, 2006). It creates a drive and dynamic muscle constriction to form a stretch and examples to these movements involve skipping, running, shuffling, and a variety of movements of picking up the intensity.

There are various studies showed benefits of DS in terms of performance such as power (McMillian, 2006; Yamaguchi, 2005; Young & Behm, 2003; Gonçalves et al., 2013; Holt & Lambourne, 2008; Thompsen, 2007), sprint (Fletcher & Anness, 2007 & Winchester et al., 2008), range of motion (Curry et al., 2009; Robbins, 2008 & Faigenbaum, 2006). Hough et al., (2009) also found that DS might improve force and power progress. Yamaguchi and Ishii (2005) stated a considerable raise in power in a leg press following DS and again Yamaguchi et al., (2007) suggested that DS routines in warm-up protocols improve power performance. As a tendency, strength and conditioning professionals started offering DS before the heavy workouts (Gambetta, 1997). For these reasons, DS has been favored lately as a pre-exercise routine (McMillian, 2006).

In addition, the literature recommends that DS before the physical exertion might develop physical capacity by extending joint Range of Motion and rising body temperature (Power, 2004). Additionally, Samukawa (2011) found that ankle dorsiflexion ROM improved drastically following the DS. This showed that DS proved to be better in improving ankle joint flexibility. Besides, Aguilar et al., (2012) revealed that DS extensively enhanced eccentric quadriceps strength and hamstrings flexibility. There are studies that show improved sprint performance after DS protocols. Turki et al., (2012) found sprint ability could be improved by executing 1-2 sets of 20 m of DS in the beginning of a workout. In a study on sprint performance, Kaetwong et al., (2012) found that stretching protocols produced significantly greater results in 50-m and 100-m sprint time than did the pre-intervention. The literature indeed recommends that DS protocols may improve power and agility scores in athletes. Ramachandran et al., (2014) state that plyometrics training combined with DS for two weeks is a useful sport specific training strategy to improve agility on trained basketball players. Little & Williams (2006) presented enhanced results in10 meter and 20 meter sprint, in addition to increased level of capacity in a zig-zag drill which measures agility.

The mainstream of researches shows that static stretching has either no effect or reduces performances while DS has either no effect or enhanced performances. These results point out that sports count on high lower body power outcome might benefit from DS in place of stretching before any exercise. This study investigated possible effects of DS, SS and no stretching (NS) on power, agility and flexibility in elite competitive wrestlers. There were limited research on wrestlers and wrestling, and the conflicting data stated that stretching protocols were detrimental to the performance (Costa et al., 2014; Cramer et al., 2005) while others presented that SS, DS or both of them helped to improve the performance (Power, 2004; Samukawa, 2011; Kaetwong et al., 2012). The literature also showed no significant relationship between three different warm-ups (DS, SS, and NS) on performance (Christensen & Nordstrom, 2008). Moreover, endurance capacity was not affected at all in elite runners following DS protocol (Zourdos (2012). Despite the research suggesting either static or dynamic stretching, there are still varying inconsistent results revealed by many researchers. Studies are still continuing about which warm-up protocol is more beneficial for competitive athletes.

1.1. Purpose of the Study

The purpose of this study was to examine the effects of Dynamic Stretching, Static Stretching and No Stretching on power, agility and flexibility in elite wrestlers.

1.2. Research Questions

What are the effects of Dynamic Stretching, Static stretching, and no stretching on Power, Agility and Flexibility in elite wrestlers?

1.3. Null Hypothesis

H_O1: Dynamic stretching, static stretching or no stretching does not have a significant effect on power values of subjects.

H_O2: Dynamic stretching, static stretching or no stretching does not have a significant effect on agility values of subjects.

H_O3: Dynamic stretching, static stretching or no stretching does not have a significant effect on flexibility values of subjects.

1.4. Significance of the Study

Stretching is an effective and determinative factor in competitive performance which is a primary goal for elite athletes. There is a controversy still remaining between SS and DS protocols in terms of their benefits in athletic performance. As one of the most difficult sports, wrestling and wrestlers, too, are needed to be examined in terms of static and DS protocols. Clearly understanding the effects and consequences of different stretching conditions on performance outcomes of elite competitive wrestlers could lead to better wrestling workouts and even to better competition results.

The study and its arguments are mainly focused on that whether dynamic and static stretching protocols, in elite wrestlers, prior to physical activity affect power, agility and flexibility performance or not. Many coaches and athletes started choosing a DS over SS in the last years. Since there is a lack of evidence on acute effects of SS and DS in wrestlers, this study will examine if one protocol supersedes the other. The result of this study would easily be used in all athletic events clubs and federations to apply the more effective stretching protocol for increasing power, agility and flexibility performances.

1.5. Assumptions of the Study

The following are basic assumptions for this study:

1. Considering the participants were being informed and presented about the stretching techniques and the range of motions, they followed and performed all the stretching routines properly.
2. Participants demonstrated their best performance throughout the tests.

1.6. Limitations of the Study

The following are limitations for this study:

1. The participants were limited to the wrestlers in Ankara region.
2. Stretching types were limited to dynamic and static stretching alone.
3. Participants were all men.

1.7. Definition of Terms

Elite Wrestlers: The wrestlers who are competing in the national level championships in Turkey.

Agility: Agility is the ability to change direction of the body or body parts rapidly under control (Baechle & Earle, 2000).

Static Stretching (SS): A slow, deliberate movement to the endpoint of the ROM that can be sustained for a period of 10 to 30 seconds (Kaminsky, et al., 2006).

Dynamic Stretching (DS): Slow movement of a joint as a result of antagonist muscle contraction throughout the range of movement (Weerapong et al., 2004)

Muscle-tendon-unit (MTU): A group of combination of a muscle, tendon, and its connective tissue properties that help force production in movements (Vetter, R. E., 2007).

Peak Power is the greatest amount of power at any point during a specific range of motion (Baechle, T.R., 2008).

Peak Torque: Maximum torque value achieved in the entire range of motion of a given movement (Perrin, 1993).

Proprioception: The perception of one's own body position and movement (Appleton, B., (1996).

Warm-up: Aerobic movements carried out before a physical event to raise core and muscle temperature and enhance actions of aerobic systems (Holcomb, W.R., 2000).

CHAPTER 2

REVIEW OF LITERATURE

This review of literature will examine the related literature on the effects of static stretching (SS) and dynamic stretching DS on power, agility and flexibility in competitive wrestlers. Researches done previously on the study topic will be analyzed and discussed to affirm this subject issue.

2.1 Stretching and its Mechanism

Stretching is recommended by coaches and other professionals for years to the athletes before the training to reach two main goals, to develop the athletic capacity and to lessen the possibility of injury. It was long believed that stretching improves athletic condition for the causes as well as increasing Joint ROM (Robbins, 2008). Shellock and Prentice (2008) showed that lacking of flexible joints and muscles may lead to actions that are inaccurate or uncoordinated. For example, a wrestler with a lack of adequate flexibility in the hamstring and hip flexor muscles might not perform an arm throw requiring hip and leg flexibility, thereby negatively affecting performance. In addition, in some sports, like gymnastics, it is needed to have a great amount of flexibility about particular joints. In the sports like wrestling, gymnastics and track and field, for the maximum successful performance the athlete should maintain the precise biomechanics with the aim of maximizing speed, efficiency or power. Any uncoordinated change in the biomechanics of the movement or technique due to the lack of flexibility may create a harmful effect on performance.

The mechanism of stretching could be one of the source or center of all the questions that we are looking for in this study. The effort should be given to understanding what is occurring physiologically when a muscle responds to a stretching force. Flexibility is simply explained with the musculotendinous unit's (MTU) ability to elongate with the application of a stretching force, determining the ROM available at a joint, (Houglum, 2001). To look into the details of this concept it is necessary to begin with the basic anatomy of the MTU.

Preventing injury in the musculotendinous unit (MTU) has been a goal of stretching (Garrett, 1990). Dynamic contracting elements (muscle fibers) and inactive element (tendon) compose the MTU which carry large forces and move through a greater ROM when the joint moves, and an extra flexible tendon could bear a great deal of energy, in that way defending the dynamic contractile apparatus and dropping the chance of injury to the muscle fibers (Garrett, 1990). Garrett (1990) found that the injury of muscle strain possibly to happen in the stage of the eccentric muscle contraction, while the force is employed to the MTU. This is normally faced in two-joint muscles.

The other factor in the stretching mechanism is known as muscle spindles, (Proprioceptors) located in the ligaments, tendons, muscles and joints are parallel to the other muscle fibers. The entire information regarding the musculoskeletal system is carried by these muscle spindles, which are the nerve endings, to the central nervous system These sensory nerves surround the muscle spindles, which produce impulses when the length and rate of the muscle spindle is altered. Proprioceptors are the basis of the entire proprioception. The proprioceptors identify every change in displacement of our body (motion or posture) and every alteration in tension or force inside the body (Appleton, 1996). After the stimulation of the muscle spindles, it forms a reflexive reaction that forces the muscle to constrict, also causing an inhibition of the antagonist muscle (Houglum, 2001, Guyton, 1996). To stop the overstretching of the muscle, the muscle contracts when it is put on a stretch. This excitation of the muscle spindles causing a reaction contraction of the extended muscle is known as the stretch reflex (Houglum, 2001; Guyton, 1996).

Different from the muscle fibers, tendon elasticity is not entirely adequate except they are viscoelastic which represents that the pressure and tension in a substance rely on the grade of burden, thus the duration of the force implementation influences the tension response of the substance (Knudson, 2007). Figure 2.1 demonstrates the reaction of a ligament which was extended to a fixed length at two paces, slow and fast. Clearly noticeable that higher speed of stretches ends in a greater stiffness than slower stretches (Knudson, 2007). When the rate of stretches increase, the stiffness also goes up in muscles and tendons. There happens a slight rise in passive resistance (high compliance) by muscle due to a slow stretch, when a faster increase in passive resistance (high stiffness) to a fast stretch will be provided by the muscle. That is why the stretching movements must be applied gradually to reduce the raise in force in the muscle–tendon unit (MTU) for a certain amount of stretch. The straight line of the graphic stands for the loading reaction of the ligament, whereas the dotted line represents the mechanic reaction of the tissues as the burden is released (unloading) (Knudson, 2007).

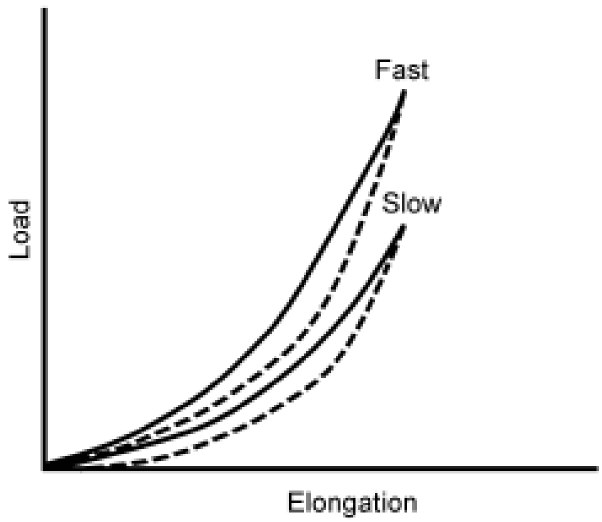

Figure 2.1 Load – Distortion curves for tendon – Fast and a slow rate stretch (Duane, 2007).

Next basic functioning unit in stretching muscles is the sarcomere, which is the starting point of the stretching of a muscle fiber and the fundamental component of contraction in the muscle fiber. When the contraction happens in sarcomere, there increases the region of overlap among the thick and thin myofilaments (Appleton, 1996). As the stretching continues, a decrease in the region of overlap is seen, providing the muscle fiber to extend. When the maximum resting length is reached by the muscle fiber (the entire the sarcomeres completely extended), further stretches place forces on the encircling connective tissue (Appleton, 1996). While the increase in stress continues, along same line of force as the pressure, the collagen fibers in the connective tissue were lined up. Therefore when the muscle is stretched, the muscle fiber is extended towards to its complete size sarcomere by sarcomere, and after that the connective tissue absorbs the remained looseness. While that take places, it facilitates to lineup remaining disordered fibers in the way of the pressure. This rearrangement of fibers is the system that assists to restore scarred tissue again to health (Appleton, 1996).

2.2. The Stretch Reflex

When there is stretch in a muscle, its various fibers extend, yet remaining fibers might stay at rest. The length of the stretched muscle depends on the fibers that are stretched (Scully, 2000). When the muscles stretch, so do the muscle spindles. The muscle spindles record the changes in size (and how rapid) and convey signal to the spine that transmit these messages. These actions activate the stretch reflex (also named the myotatic reflex) that challenges to defend against the changes in muscle size through making the stretching muscles to flex. When the alteration in the muscle length become fast, then it means that the muscle contraction tends to be more powerful. The training for plyometric sand jumps is derived from this rule. This necessary mission of the muscle spindle helps to maintain muscle tone and to protect the muscle from injuries (Appleton, 1996).

One of the purposes to keep the muscle stretched for an extended time is that when someone seize the muscles in the stretched spot, the muscle spindle adjusts (become adapted to the latest size) and diminish its signals. Progressively, you could prepare the stretch receptor to tolerate larger extension of the muscle (Appleton, 1996). According to some research, a number of muscles stretch reflex might be restricted with extensive training, in order that there occurs slight or no reflex contraction in reply to a rapid stretch. Despite that these forms of controls offer the chance for the maximum increase in flexibility, which as well presents the maximum possibility of damage when performed incorrectly. For that reason, just totally trained individuals and performer on the peak of their capacity are assumed to truly have that point of muscular controls (Appleton, 1996).

2.3 Dynamic Stretching

DS is a procedure involving the performance of movements ranging from low to high intensity and intended to raise core body temperature, improve excitability of motor units, develop kinesthetic consciousness, and magnify the dynamic ROM (Faigenbaum, 2006). Due to large number of studies and evidences in favor of DS related performance increases, coaches and athletes started to choose DS instead of SS (Baechle, 2008). DS applies a drive and active muscle contractions to create a stretch, and these movements involve skips, directive runs, shuffles, and a variety of exercises of escalating intensities.

There are various studies performed on effect of DS on outcomes of different performances with either positive or negative results. Various studies recommend that DS before the physical activities might advance performances through extending joint ROM and core body temperatures, resulted in improved flow in blood to the muscle and more rapidly nerve-impulses transmission (Power, 2004). Athletic coordination may also be improved by DS that simulates movement pattern involved in sports and thus giving opportunities for sports-specific skill rehearsals (Fletcher, 2004). Additionally, some studies showed improvement in specific performances following DS recorded in jump performance (Fletcher, 2007), sprinting performance (Church, 2001), and maximum force producing capacities (Thacker, 2004). Again in another study, increased coordination and balance were resulted by a moving on from average to higher intensity DS (Little, 2006).

The study on flexibility has been carried out by Samukawa (2011), in which the effect of DS on the ankle muscle tendon features by means of using ultrasonography was investigated. DS of plantar flexor for 30 s was performed and repeated in 5 set. ROM measurements were done before and following DS. The findings in the displacements of myotendinous junctions (MTJ), pennation angles, and fascicle lengths were as well analyzed with ultrasonography. They found that ankle dorsiflexion ROM showed significant improvement following DS ($p < 0.0001$). They noted that DS has been revealed to become successful in extending the flexibility in ankle joints. Therefore, for lengthening the tendon tissues, which is essential for wrestlers and for many other sports fields, DS of the plantar flexor was regarded to be useful. Ankle joint flexibility is an important component in soccer, gymnastics, track and fields and etc.

Hamstring flexibility is essential for almost every single sport and in many times defining the winners. In addition to its positive effect in the ankle joint flexibility, Aguilar et al., (2012) analyzed the acute effect of DS warm-ups (DWU) and SS warm-ups (SWU) in flexibility and power. 45 subjects with random assignment were placed in a control (CON), SWU, or DWU groups. Consistent with the above literature, they found significantly increased hamstring flexibility (pre: 26,4 ± 13,5°, post: 16,9 ± 9,4°, $p < .0001$) and peak torque in eccentric quadriceps (pre: 2,49 ± 0,83 N·m/kg, post: 278 ± 0,69 N·m/kg, $p = 0.04$) in the DWU results. For the CON and SWU, no significant effect was recorded in strength, flexibility or vertical jumps ($p > 0.05$). Significant improvement in eccentric quadriceps strength and hamstring flexibility after DWU. Therefore, it was stated that the DWU might become a superior pre-activity warmup selection than an SWU.

In a different ROM study, the expansion in passive ROM due to DS supports the above findings. Herda et al., (2013) examined the effect of the DS on passive-biomechanical features and knee flexor isometric muscle strength. 14 subjects (age = 24 ± 3 years) executed passive ROM assessment and isometric max. deliberate contraction of the knee flexor on knee joints with the angle of 35°, 50°, 65°, 80°, and 95° under complete knee extensions prior and following DS. They found that passive ROM improved at the same time as passive stiffness and passive resistive torque lowered after DS. Max. torque declined at knee joint angle of 65°, 80° under complete extensions. The researchers concluded that DS ended in differences to passive stiffness and passive resistive torque which are normally informed after SS.

The positive results on sprint performance are one of the important indicators of the benefits of DS protocols. Behm et al., (2011) investigated the effects of various SS periods after DS in repeated sprint ability (RSA) and change of direction (COD). They assigned 25 subjects for the RSA and COD protocols with a random order. Following a 5 minutes warm up, they had subjects executed SS protocols of 30, 60 or 90 seconds (3 stretching x 10, 20 or 30 seconds). Three 30 seconds DS exercises were carried out (total of 90 seconds). Sit and reach test was handled prior to the aerobic warm-up, following the combined static and DS, and after the RSA/COD protocol. They revealed that the time period of SS revealed positive effects with 36.3% flexibility improvement plus also found out that the sit and reach score with the 60 and 90 seconds SS protocols was greater (85.6%) than the condition with the 30 seconds duration ($p \leq 0.001$), but among the 3 stretching protocols there was no significant difference in RSA and COD outcomes.

In a similar study performed on sprint performance, Turki et al., (2012) later studied the effects of warm-up integrating various measures of DS on 10 and 20 meter sprinting performance in elite athletes. Sixteen subjects finished a warm-up with a 5 minute jogging prior to performance of three pre-intervention measures of 10 to 20 meter sprints. They did not find a significant time, condition, and interaction effect above 10 meter sprints. However, in terms of 0 to 20 meter sprint times, there was significant main effects for the pre and post measurements ($p<0.002$), the DS protocol ($p=0.004$) and an interaction effect ($F=41.19$; $p=0.0001$) were measured for the 0 to 20 meter sprint times. Their study results showed that to perform 1 or 2 sets of 20 meter DS in a warm up might improve 20 meter sprinting performances. Their findings proposed that dynamic stretches have positive effect on the short distance sprinting performances which is consistent with the previous research.

In addition to the sprint performances following stretching protocols, Fletcher and Jones (2004) investigated the performance of 20 meter sprints in rugby players to compare the effect of SS and DS protocols. They tested the subjects following finishing the 10 minutes low intensity jogging, and afterwards completed a SS or a DS protocol. They found that the subjects experienced the SS treatments showed significant scores in the sprints. In contrast, the players in the DS group significantly decreased their sprint time. In the recent study of Fletcher (2007) revealed related outcomes in elite sprinters. They improved their short distance sprint time following a warm up that involved DS. Overall, the researchers recommended that the developments found following DS might be as a result of the practice of the particular movement samples in the DS protocols, and as well assumed that DS might permit for a further optimum switch from eccentric to concentric muscle actions, increasing explosive force productions.

The research did reveal consistent and significant indications that jumping performance as a measure of power has been positively affected by DS. In a study on sprint performance, Kaetwong et al., (2012) compared the effect of warm-up with-and without-DS on sprint time and vertical jump performance. They hired fourteen healthy subjects aged 18-25 years old and they executed two modified warm up protocols: dynamic warm up (DWU) and DWU with DS (DWU+DS). Warm up procedure involved a 10 minute jogging and 3x30-m sprints. The DS comprised of heel flick, high knee, hip roll, walk on toes, alternate direct leg skip, walking lunge and adapted walking lunge. Consistent with the previous research, they found that both warm-up protocols produced a significant sprint time ($p<0.05$) in 50-m and 100-m than did the pre-intervention. The jump height changed insignificantly ($p>0.05$) after completion of either warm-up incorporating DS or warm-up only.

The literature certainly suggests that DS protocols may improve power and agility scores in athletes. Ramachandran et al., (2014) carried out the study with thirty professional basketball players to see the effect of short period lower intensity plyometric movements together with DS protocol in vertical jump performance and agility score in elite basketball players. They found statistically significant improvements in vertical jump height (31.68±11.64 to 37.57±16.74; $P<0.012$) and agility (16.75±2.49 to 15.61±2.80; $P<0.00$) observed between pretest – posttest measures. They finally concluded that plyometric training combined with DS for two weeks is a useful sport specific training strategy to improve vertical jump performance and agility in elite basketball players.

One of the other supporting studies recommending DS in elite athletes was revealed by Little and Williams (2006). In this sprint and agility study, elite football players performed four DS movements for 60-seconds, ended in enhanced performances in stable start 10-meters sprints and moving start 20-meters sprints, in addition to enhanced performances in a zigzag test assessing agility. McMillan et al., (2006) as well stated that DS including movements of calisthenics (for instance bending & reaching, squat, lunge, pushup) and drills including movements (for instance shuffles, high knees, carioca, and continuing acceleration) finished in significantly enhanced agility outcomes in T-drills, power scores in medicine ball throws, and explosive power scores in 5-step jumps in elite players. According to the results, they recommend that DS movements might be useful in enhancing performances across various athletic events. Besides the athletic improvement revealed in elite players, DS also leads to improved results in recreationally trained participants. Yamaguchi and Ishii (2005) presented significantly increased power in a leg-press testing after DS involving 15-repetitions of 5 stretching.

The literature is consistent in power scores after DS intervention. This study by Yamaguchi and his colloquies also supported this consistent literature on power. Yamaguchi et al., (2007) investigated the effects of DS exercises on performances for the period of isotonic (DCER) muscle action in different weights. Leg extension power output was tested in sedentary male participants following the pretreatments. The pretreatments were: (a) DS with 2 kinds of movements of leg extensors and the other 2 kinds of DS movements imitating the leg extension movement and (b) non-stretching treatments by waiting for 8-minutes just sitting. They found that the DS intervention created a significant power output ($p < 0.05$) superior than the no-stretching treatments in every load. The findings of this research showed that DS protocols, such as, DS exercises and DS exercises imitating the real movement model, might significantly develop power outcome with isotonic muscle action under different loads. The researcher mainly recommended that DS protocols in warm up improve power performances since regular power moves are performed by isotonic muscle actions with different loads.

It does seem, according to the previous studies, that DS appears to have a potential to be a beneficial sport specific warm-up or a part of training. Equally important, Colak (2012) studied the effect of DS on isokinetic hamstring (H) strength, quadriceps femoris (Q) strength, and the H/Q ratio in trained female football players. 15 subjects joined in the measurements. The researcher stated that DS has positive effect in strength of muscles, H/Q ratio and range of motion. With these findings, we can say that DS might enhance performances and decrease the injury risk to athletes.

Gourgoulis et al., (2003) tested potentially better athletes as participants prior to and following performing a steady progressing of sub-maximal half squat, extending from 20% to 90% of 1RM. The researchers revealed that following the half squat, participants showed significantly increased height (+2.4%) in counter movement jump (CMJ). The participants were separated into two groups on the basis of ability in pre squat jumping. Following separation, they also acknowledged that the stronger group (the ones with superior jumping ability) improved CMJ height by about of 4.01%, more than the lower ability jumping group, which only improved CMJ height by an about 0.42%. As consistent with the previous literature, they concluded that for powerful, physically superior athletes, DS might have considerable performance improvements.

There seems to be limited and inconsistent research stating that stretching protocols are detrimental to the performance. Despite of the many benefits of DS on performance supported by the previous literature, there have been some reported disadvantages or no effect on the performance values following DS. An example to a no-effect study performed by Christensen and Nordstrom, (2008) who studied power, did not find a significant relationship between three different warm-ups. Christensen and Nordstrom (2008) studied the effect of proprioceptive neuromuscular facilitation (PNF) and DS exercises in vertical jump ability. The warm-ups in the study involved a 600 meters jogging, a DS routine following 600 meters jogging, and a PNF protocol following 600 meters jogging. Sixty-eight men and women executed three vertical jumps after every warm up protocol. The researchers stated that there was the protocols did not significantly affect the combined ($p = 0.927$), men's ($p = 0.798$), or women's ($p = 0.978$) performances. They concluded that vertical jump performance has not been affected significantly by the 3 different warm-ups. They have also not found any gender difference after the 3 different warm ups.

The review of literature reveals opposite or contradictory results concerning the effect of stretching in performance. As an example to that, Zourdos, (2012) researched the effect of DS in energy cost of running and endurance capacity in elite athletes (runners). They performed a preload running for 30 minutes at 65% VO2max and a time trial for 30 minutes to evaluate energy cost of running performance, with fourteen male runners. The participants performed either a trial after 15 minutes of DS or quiet sitting. Their findings revealed that they did not find significant differences in the covered distances after sitting condition (6.3 ± 1.1 km) compared with the stretching (6.1 ± 1.3 km). According to above results, they recommended that DS might not affect running endurance outcomes in elite male athletes. In a similar study supporting the above research, Mojock et al., (2011) studied the effect of SS in economy of running and endurance performances in elite female athletes. Participants joined two sections of 60 minutes running following random grouped SS routine or just sitting. They found that the SS assessed by sit and reach test improved flexibility but showed no effects on economy of running, calorie expenditures, HR or endurance performances. They concluded that stretching did not create undesirable effects on endurance performance in elite women athletes, which means that the declines in performances previously revealed with stretching might not take place in elite women athletes.

A different view was revealed in a study by Costa et al., (2014) suggesting DS as detrimental to the performance. They examined the effect of DS in peak torque of leg muscles and hamstring - quadriceps (H:Q) ratios. 21 female subjects were assigned and they executed max. isokinetic leg extensions, flexions, and eccentric hamstring action at different velocity levels prior to and following a DS of hamstring and quadriceps in addition to the control measurement. They found that peak torques after leg flexions were lowered in both the control and the conditions, while the DS intervention decreased eccentric hamstring peak torque ($P \leq 0.05$). These results of DS reducing the strength in leg muscles are not widely supported by the literature, however, coaches, trainers and athletes might be careful when recommending and applying DS protocols rather than SS to maintain muscle force.

2.4 Dynamic Stretching and Other Stretching Routines

The literature also reveals various studies that researched the relationship between different stretching conditions have displayed varying results. An investigation for analyzing different stretching procedures for efficient warm up was needed. For the reason of comparing different stretching protocols, such as, ballistic and DS, Jaggers et al., (2008) compared the difference between the ballistic stretching and the DS protocols in vertical jump outcome. They assigned 20 healthy mix gender university students aged from 22 and 34 (24.8 ± 3 years). The results showed no significantly affected jump height, force, or power when compared no-stretching with ballistic stretching. They found significantly differed jump power when compared no-stretching with DS, but they found no significant difference for jumping distances or forces. The researcher stated that neither DS nor ballistic stretching could produce a boost in vertical jumping distances or force. On the other hand, DS induced gains in jump power post-stretch.

There also seems to be a debate on whether there are significant effects of passive, active and DS on performance. Carvalho, (2012) examined the acute effects of these three dissimilar stretching techniques united with a warm up routine in VJ executions. They assigned 16 tennis players (14.5±2.8 years) to 4 special investigational setting on 4 consecutive days. They used different sessions and every session involved a common and specific warm up, with 5 minute of runs pursued by 10-jumpping, attended by one of the five protocols. Following the interventions, the participants executed 3 squat-jumps (SJs) and 3 countermovement-jumps (CMJs). They stated that the testing showed significantly decreased scores for active stretching (ASC) (28.7±4.7 cm; p =0.01) and passive stretching (PSC) (28.7±4.3 cm; p =0.02) condition when comparing with control condition (29.9±5.0 cm) for the squat jumps. For countermovement jumps, they did not find a significant decrease (p>0.05) when all stretching conditions were compared with the Control Condition. Significant improvements in squat jumps performances were recorded when comparing the dynamic stretching condition (DC) (29.6 ±4.9 cm; p=0.02) with PSC (28.7±4.3 cm). Significant increases in countermovement jumps performance were observed when compared the condition ASC (34.0±6.0 cm; p =0.04) and DC (33.7±5.5 cm; p =0.03) with PSC (32.6±5.5 cm). The results presented that the DS protocol come out to be better as a warm up procedure in young athletes.

In sum, the data suggests DS has greater applicability to enhance performances in force productions, jumping performances, coordination, sprints speed, flexibility and agility drills.

2.5 Static Stretching

SS involves a slow, deliberate movement to the endpoint of the ROM that can be sustained for a period of 10 to 30 seconds to train the neuromuscular responses of the sensory receptors within the muscle, usually explained as the peak right before the onset of pain (Kaminsky, et al., 2006). Researchers have quite well documented that athletic performance and injury risk can be adjusted by the protocol of a pre-exercise routine before intense physical activity (Alter, 2004). For that reason, every single detail in stretching and warm-up routines may have ability to change the outcomes of any competitive athletic performance.

When applied properly, the static stretch provides the relaxation and concurrent elongation of the stretch muscle, and the risk of injury caused by the stretch is decreased (Baechle & Earle, 2000). It is proved that SS improves ROM (ROM) and could also diminish musculotendinous stiffness, even during short-durations (5–30 s) stretches (Bacurau, 2009). SS is advised by some institutions and individuals like NSCA, holding SS for 30 seconds is recommended by the National Strength and Conditioning Association (NSCA) (Baechle, 2000). Additionally, American College of Sports Medicine (ACSM) suggest keeping a stretch for about 15 to 30 seconds in their guidelines, and declares that no additional development in flexibility is recorded after 30 seconds stretching (ACSM's Guidelines for Exercise Testing and Prescription, 2005).

According to the literature, there are some theories trying to explain why SS produces a harmful outcome in the performances like speed and power. One of the reasons of the decreases in performance assessments is the decline in rigidity in musculotendinous units that leads to a raise in tendon slacks that demands additional time to be taken in after the muscles contract. The mentioned tendon slacks leads to a reduced efficient convey of force from the muscles to the levers (Avela, Kyrolainen, & Komi, 1999). Furthermore, the neurological sensitivity is affected negatively by static stretching, which result in declined neural drives to the muscles that equate to declined muscle activations in stretch reflexes (Avela et al., 1999). Another essential point is the amortization phases, which are called the transitions between the eccentric loadings and the beginning of the concentric muscle actions. To efficiently consume up the accumulated energy of the eccentric loadings, the amortization phases should end in short durations. If the amortization phases are excessively lengthy, the accumulated energy from the eccentric phases is vanished and spread out as heat (Potach, 2004). This energy loss in the eccentric loading may results in decreased performance in the athletic events.

In a similar study, Cornwell et al., (2002) researched the effect of stretches on the rigidity and muscles activations of the triceps surae muscle groups through maximum single joint jumping with movements limited to the ankle joints. They hired 10 male subjects for both static (SJ) and countermovement (CMJ) jumps prior to and following passively stretching the triceps surae. They revealed significantly decreased ($P<0.05$) jump height for the CMJ, but they found no significant ($P>0.05$) change in jump height after single-joint jump. They found, on the contrary, that the single-joint jump showed a significantly ($P<0.05$) decreased IEMG, however the IEMG for the CMJ stayed unaffected ($P>0.05$). They also discovered a small but significant decrease ($P<0.05$) in stiffness. To sum up, the researcher stated that an acute session of stretching may create a negative performance on a single-joint CMJ. The consistency can be seen with the many other studies carried out on the SS that SS routines have detrimental effect on the power outcomes.

An area that should not be overlooked when studying SS is that it is to look into the reasons of fundamental factors leading to performance decrease after SS. In order to gain a better knowledge of that, Behm et al., (2001) investigated the reasons underneath the loosing force happening following extended, static, and passive stretching. They tested the participants prior to and 5-10 min after 20 minutes of static, passive quadriceps stretching (N=12) or a period of no stretching (control, N=6). They used the following measurements; isometric maximum voluntary contractions (MVC) force, electromyographic (iEMG) activities of the quadriceps and hamstrings, awakened contractile possessions (tetanic force and twitch), and quadriceps deactivation as assessed by the interpolated twitch technique (ITT). After the testing they found significantly decreased MVC for 12% with not a significant change in the control measurements. They also found 2.8% and 20.2%, respectively, muscle deactivation assessed by the ITT and iEMG. While twitch forces significantly went down to 11.7%, they did not get any change in tetanic force post-stretch. They concluded that even though possible increase in the muscle compliances influenced twitch force and a lack of tetanic force alteration might recommend that post stretch force decreases are further influenced by muscles deactivation than change in muscles elasticity.

A part that must not be ignored when investigating the effects of SS is power performances. In a study of power, Reiman et al., (2008) researched the effect of SS on maximal torque productions of the quadriceps. The study hired 47 university students of both genders. Maximal torque of the leg was assessed before and following a 30 second passive SS. They did not find significantly improved differences between the participant's outcomes before and following the 30 second stretching section. Their study did not also find considerable differences in power scores among age, height, weight or sex. The researcher concluded that the type of stretching has no effect in power in college students. Moreover, in a study done by Carter et al., (2008) the testing has been done to find out whether a 30-second and 60-second SS of hamstring produce differences in torque by a hamstring curl. They hired fifty subjects (13-males, 37-females) in age of 20 and 29, allocated into two groups of a 30-second and a 60-second SS of hamstring groups. They revealed that there was an overall increase in torque production with stretching. Their results demonstrated no significant differences (p=.513) between the 30-second and the

60-second SS groups with respect to the improved torque productions following the stretch protocols. There were also no considerable differences in maximal torque productions in a 30-second and a 60 second SS of hamstring. Although, many researchers reported reduction or no effect in maximal torque productions due to the stretch protocols, according to this study, stretching for either 30-seconds or 60-seconds, resulted a raise in maximal torque productions of muscles. Those findings are not consistent with the findings reached by Reiman et al., (2008), Siatras et al., (2008), Cramer et al., (2007) Samuel et al., (2008), Yamaguchi et al., (2006).

In the study performed on explosive force and power, Young and Behm (2003) studied the effect of running, SS of the leg extensor and practicing jump on explosive force productions and jumping performances. They hired 16 subjects in 5 special warm ups in a randomized way before the performances of 2 jumping trials. They found that the stretching warm up produced the least scores and the run or run + stretch + jump warm ups created the greatest scores of explosive force productions. There was no significant difference ($p<0.05$) in the control and run + stretch warm ups, while the run produced considerably superior values than the run + stretch warm up in height of drop jumps (3.2%), height of concentric jumps (3.4%) and maximal concentric forces (2.7%) and rates of force improved (15.4%). They concluded and stated that sub-maximum run and practice jump had positive effects while SS had defective influences on explosive forces and jump performances. They recommended that SS might be alternated with other protocols which may be placed in warm ups before power events.

Another power research carried by Gonçalves et al., (2013) to evaluate the effect of SS on peak force, peak rates of force developments and integrated electromyography (iEMG) on sedentary people (65±4 years). They applied 2 movements (leg press and knee extension) following the condition of stretching and the control. The researcher did not find any significant difference in peak force and peak rates of force developments in the single and multiple joint movements. Furthermore, they have not found any significant interaction in the iEMG activities (conditions vs. times; $P > 0.05$) in the single and multiple joint movements. In summary, they stated that stretching of quadriceps did not influence the peak force, peak rates of force developments and EMG activities in older women during single and multiple joint movements. Just like in results of elite athletes following static stretching, sedentary people also responded with similar outcomes after the SS routines.

There was a recent study performed to determine the effects of SS on power, Robbins and Scheuermann (2008) studied the relationship between varying amount of SS on the jump performances. 20 college athletes performed three special stretch protocols and 1 control measurement each on a separate day in a within treatment experiment. They used the stretching protocols involved of the stretch sets of 2, 4 or 6 with the stretches kept for 15-seconds with a 15-seconds break. They used the muscle group of the quadriceps, hamstring, and plantar flexor. They found that the scores after 6 sets were significantly less than the scores before-6 sets ($p \leq 0.05$). In addition, the scores following the 6 sets were significantly less than Pre-4 sets, Pre-2 sets, and Pre-control ($p \leq 0.05$). None of the other protocols created significant differences. The researchers did not recommend 6 set of stretching or the stretching for 90-seconds per muscle groups prior to power events, for example, jumps where the best performance is expected.

Another sample study to the detrimental effect of SS on performance was carried by Siatras and his colleagues (2008). They studied the effects of diverse SS periods on quadriceps maximal torque productions. They hired five equal groups with 50 participants and they were randomly grouped into various durations (no stretching, 10 seconds, 20 seconds, 30 seconds, and 60 seconds stretching). After the testing, they found significantly increased knee joint flexibilities ($P < 0.001$) and isometric, isokinetic maximal torque reduction. They showed that significant maximal torque reduction ($P < 0.05$-0.001) occurred simply following 30 and 60-seconds of quadriceps SS. Stretches also decreased isometric maximal torque with 8.5% and 16.0%, respectively, and isokinetic maximal torque following 30 and 60 second of stretching was decreased. They explained that torque reduction are connected to alterations of the muscles neuromechanical characteristics and they finally suggest that SS movements of muscle groups with longer than 30 seconds of time should be refrained prior to athletic performance demanding maximum strength.

On the contrary to the results of Siatras et al., (2008), Egan et al., (2006) revealed no effects on torque and mean power scores following SS. They examined the effect of SS on peak torque (PT) and mean power output (MP) in maximum leg extensions in athletes. They hired eleven subjects to join maximum leg extension test. The post-stretching measurements were performed at minutes of 5, 15, 30, and 45 following the SS were recorded by dynamometer software. After testing section, they found no stretching related change in PT ($p=0.161$) or MP ($p=0.088$) from before and after stretching protocols in the test periods. They concluded that the SS created no effect in PT or MP throughout the maximum, isokinetic and concentric action in muscles for college women basketball players. Comparing to the earlier researches, these outcomes revealed that elite and skilled players might not suffer from the lack of stretching induced force than inexperienced and non-athletes. The findings of the previous research and this similar study, conducted by Cramer et al., (2007), had consistent outcomes. Cramer et al., (2007) examined the effect of SS on maximal torque, the joint angles at maximal torque, power outputs, and power in vastus lateralis and rectus femoris muscle in maximal muscle action. They hired 15 subjects (age = 23.4 ± 2.4) to perform maximum eccentric isokinetic muscle performances of the knee extensor muscles. After testing, they found no stretching related change in maximal torque, the joint angles at maximal torque, power outputs ($P>.05$). We can conclude that according to these results, SS might not influence maximum torque and power productions, and it might not also alter muscle activations.

A study carried out by Mizuno et al., (2014) researched the effects of SS and what happens after the training involving the SS protocol. They studied to explain the time-course of the stretching-related decline in maximum torque of the isometric plantar flexions. They hired nineteen women for 2 random ordered experiments: 5-minutes SS or no stretching as control measurement. The testing was applied pre-interventions; instantly post-interventions; and 5, 10, 15, and 30 minutes post-interventions. Their test results revealed that the maximal voluntary contractile (MVC) torque showed significant decline directly after, and in 5 minutes following the 5-minutes SS protocol comparing with the preintervention significance ($p < 0.05$). However, that decline regained in 10 minutes. According to these results, the researchers propose that the deficit of SS is disappeared shortly after SS. This result is also an indicator that the negative effects of SS have a potential to affect the athletic performance right after the stretching itself.

In addition to torque, power and ROM studies after SS routines, a sprint ability study carried out by Beckett et al., (2009). They researched the effect of SS in the recovering period of field based team events in successive repeating sprint abilities (RSA) and changes of direction speed (CODS) performances. In the 4 different times, 12 team sport athletes assigned for a standard warm up, preceded with a testing of RSA or CODS in a counterbalanced study. They used 3 sets of 6 maximum sprint trials in both tests with a 4-minute recovery among them. The subjects either just sit (control) or finished a SS protocol during break between sets. They also used the tests; the RSA tests (straight line sprint), and the CODS tests (a changing of directions) every 4 meters (totals of four). They found constant tendencies for RSA durations to be slow following the SS intervention. Additionally, sprint durations again inclined to be slow at the CODS-SS trials comparing to the CODS-CON against all sprinting alternatives. On the contrary to the results of the study by Turki et al., (2012) suggesting the DS as a beneficial protocol on sprint performance, in this study, the researchers suggested that an acute bouts (4 minutes) of SS of the lower limb in recovery period in the attempts might endanger repeated sprint ability performances but showed lesser effects on change of direction speed performance.

Another parallel sprint study by Kistler et al., (2010) was carried out to examine the effect of SS vs. no stretching on the 60-meter and 100-meter sprint performances of university athletes following a DS warm up. They hired 18 participants for each stretching protocols in counterbalance orders in the tests. At the end of the SS or no stretching protocol, the participants instantly executed two 100-meters measures with timing points placed at 20, 40, 60, and 100 meters. They found consistent findings with the literature revealing detrimental effects of SS and showed once more significantly slowed performance with SS ($p < 0.039$) in the next 20 meters (20-40-meters) of the sprinting tests. Following the initial 40 meters, SS showed no further detrimental effect in performance of the 100-meters sprinting. The researcher states that it seems detrimental to involve SS in the beginning as warm up protocol for sprint athletes in distance up to 100 meters.

A strength study after SS was carried out by Costa (2009) to confirm the influences of SS in maximum strength in jiu-jitsu players. Twenty jiu-jitsu players (age = 24.1 ± 1.8) were joined. There were 2 separate tests, maximum strength test (1RM) in bench press movement, with SS and no SS protocols prior to the assessment. The participants performed 3 SS movements in 3 sequences of 20-seconds each, with the sum 180-seconds of SS for the major muscle grouping concerned in bench pressing. The researcher revealed that after the stretching conditions, the participants' the maximal load was 78.3 ± 17.9 kg, and in the no-stretching protocol, the max. weight was 85.8 ± 17.8 kg. 1RM scale was 8.75% lower ($p<0.001$) in the SS protocol. The researcher concludes that the SS protocol used in this study produced detrimental effects on the maximum strength in the evaluated participants.

Yamaguchi et al., (2006) studied the effects of SS on muscular performances in dynamic constant external resistance (DCER) muscle action in a variety of weights. They measured concentric DCER power outputs during leg extensions in twelve participants following 2 sorts of pre-treatments. They used the following pre-treatments (a) SS treatments involving 6 kinds of SS for leg extensor and (b) non-stretching treatments with a sitting for 20-minutes. They used three different weights in assessments of the power outputs from the maximal voluntary contractile (MVC) torque of 5, 30, to 60% with isometric leg extensions in all subjects. They found that the maximal power outcomes after the SS protocol created significant ($p < 0.05$) lower values than that after the non-stretching treatments in every weight. The researcher concludes that moderately extensive SS significantly diminishes power outcomes with concentric DCER muscles actions in different weights. As a result, they state that the outcome of the current study recommend that fairly extensive SS lower power performance which is in consistent with the previous literature.

On the contrary to many studies, as one of the few researches, Handrakis et al., (2010) recommended SS for active middle-aged adults. They studied the effect of SS protocols in balance and jump-hop performances in sedentary participants. They hired 10 middle aged participants. In the protocol, the participants did stretching for 10-minutes with a 30-seconds holding, in the control protocol, they sat for 10-minutes. They did not find any significant differences in the group's means of the stretching and no-stretching protocols in the long jumping, single hopping, triple hopping, crossover hopping, and 6-meters timed hopping performances. They concluded that 10-minutes of acute SS develops balance and might not change jump-hop performances in middle aged subjects, for that reason, SS might be integrated prior to athletic events and exercises in health activities of middle aged people.

There seems to be limited research investigating the time-course of the effect in athletic performance. For this purpose, Wolfe et al., (2011) studied the time-course of SS in economy of cycling. They hired 10 elite endurance cyclists. They had three appointments for baseline tests of the cycling VO2max, stretching and no-stretching prior to a 30-minutes fixed cycling at 65% of their VO2max. The protocol for stretches involved 4 30-seconds sequences of 5 stretching for totality 16 minutes stretching period. The researchers stated that a significant condition by time interaction was found in VO2 with the 5-minutes time duration with significantly lesser in the non-stretching protocol (32.66 ± 5.35 ml·kg−1·min−1) than stretching (34.39 ± 5.39 ml·kg−1·min−1). With the increase in submaximal VO2 after static stretching, they suggested that trainers and cyclists might exclude SS instantly prior to higher intensity cycling since it decreases acute cycling economy.

In a similar study, Damasceno (2014) investigated the pacing strategy of the athletes to find out if SS may change pacing strategy and performances in a 3 km running time trial. They hired 11 elite distance runners. The protocol involved a) a constant speed running trial with no prior SS and a maximum progressive treadmill trial; b) constant speed running trial with prior SS; c) a 3 km time trial adaptation on an outside 400-meters course; d and e) two 3 km time trials, one with SS (investigational condition) and the other with no (control condition) prior SS. After the testing, they found that the general running times did not differ with the conditions (SS 11:35600:31 s; control 11:28600:41 s, $p = 0.304$), however the initial 100 meter was completed with a significant lesser velocity following SS. Also, SS decreased drop jump height (29.2%, $p = 0.001$). In summary, they stated that SS damaged neuromuscular functioning, which caused a slower take off in a 3 km running time trial.

2.6 Static Stretching Comparing To the Other Stretching Routines,

Although there are still some contradictory evidences regarding the benefits of static and DS, different stretching protocols were also used by Pacheco et al., (2011) to compare SS with static passive stretching (P), proprioceptive neuromuscular facilitation (PNF), static active stretching in passive tension (PT) and static active stretching in active tension (AT). Pacheco et al., (2011) examined the short term effect of diverse stretching movements in the warm up section on the lower limb. They hired forty-nine subjects in the tests which included a (prior) jumping test, standard warm up, intervention and (after) a jumping test and all participants joined to all of the 5 stretching and testing. The jumping tests were utilized to measure the squat jumps, countermovement jumps (CMJ), elasticity index (EI), and drop jumps. The results revealed significant difference ($p < 0.05$) in the interventions "P," "PNF," and "TA". Simply the "P" condition displayed significant differences (p =

0.046) in "EI," by the post-value being lesser. Similarly, significant difference ($p < 0.05$) was found in the "CMJ" measurement for the period of the intergroup analyses, particularly in "NS" and the intervention "P," "PNF," "AT," and "PT,". The researchers state that the findings of this study recommend static active stretching in AT through the warm up for explosive force events.

In another recent study on alternate stretching protocols to find out the most suitable stretching routine during warm-up phase before explosive exercises, Kirmizigil et al., (2014) researched 3 different stretching techniques: (a) ballistic stretching (BS), (b) proprioceptive neuromuscular facilitation stretching (PNF) + BS, and (c) PNF + SS on vertical jump (VJ) performances. They used 100 male participants in the experiment. All participants applied aerobic warm up (5-minutes jogging) following the BS (5-seconds for all stretching exercises), PNF + BS (PNF executed preceded by 5-seconds of BS), and PNF + SS (PNF executed preceded by 30-seconds of SS) treatment protocols. The stretching routines were carried out for 4 sets bilaterally. After a 2-minute rest, the participants applied three performance of VJ tests preceded by any of the treatments. 3 groups were formed based on their flexibility and prejump performance following warm up. The results showed significance for all individual groups and the entire group following all protocols. The researchers found that ballistic stretching improved the VJ performances in the group with lower and average flexibility, lower prejumping performances, and also in the entire groups ($p \leq 0.05$). They also stated that proprioceptive neuromuscular facilitation stretching + BS influenced the VJ performances in the groups of participants with higher flexibility ($p \leq 0.05$). However, proprioceptive neuromuscular facilitation + SS lowered VJ performances in the group of participants with higher flexibility, fair, and higher prejumping performances and in entire groups ($p \leq 0.05$). They conclude and suggest that ballistic stretching routine increased VJ height, because of that, it looks to be more beneficial than PNF + SS and PNF + BS prior to exercises that count on explosive power as a component of warm up stage.

Another study done by Barroso et al., (2012) on the alternate stretching routines to evaluate the effect of SS, ballistic stretching (BS), and proprioceptive neuromuscular facilitation (PNF) stretching on maximum strength, amount of repetitions at a sub-maximal weight, and total volumes in a multiple set resistance exercise bouts. They hired 12 strength trained men (ages = 20.4 ± 4.5) to join in the experiment. They set 4 investigational sections to assess maximum strength in the leg presses (i.e., 1 repetition maximum [1RM]) following all stretching conditions (SS, BS, PNF, or no stretching [NS]). They also set the four experimental protocols by the amount of repetitions applied at 80% 1RM to be measured following all the stretching conditions. They found that the entire stretching protocols significantly enhanced the Range of motion (ROM) in the sit and reach test when comparing with NS. Further, PNF made significant alterations in the sit and reach test than BS did (4.7 ± 1.6, 2.9 ± 1.5, and 1.9 ± 1.4 cm for PNF, SS, and BS). The PNF also caused decreased leg press 1RM values (5.5%, $p < 0.001$). Interestingly, they presented that each stretching protocol significantly declined the amount of repetitions (SS: 20.8%, $p < 0.001$; BS: 17.8%, $p = 0.01$; PNF: 22.7%, $p < 0.001$) and the entire volume (SS: 20.4%, $p < 0.001$; BS: 17.9%, $p = 0.01$; PNF: 22.4%, $p < 0.001$) when comparing to the NS. The researchers conclude that stretching routines may not be executed before a resistance training to stay away from a decline in the amount of repetitions and entire volumes. Also, the athletes who train strength exercises might face lowered maximum dynamic strength following PNF stretching.

It is however, vital to remind the limitation of SS on performance outcomes for the coaches and athletes. Bacurau et al., (2009) studied the effects of a ballistic and a SS routine on lower limb maximum strength. They hired 14 active women participants (age = 23.1 ± 3.6 years) to perform 3 investigational protocols: a control section (45° leg pressing, one-repetition maximum, 1RM), a ballistic section (20-minutes of ballistic stretching and 45° leg pressing 1RM), and a static section (20-minutes of SS and 45° leg pressing 1RM). Following the testing, they clarified that maximal strength declined after SS (213.2 ± 36.1 to 184.6 ± 28.9 kg). However, ballistic stretching did not change maximal strength (208.4

± 34.8 kg). They stated that SS exercises produced better acute improvements in flexibility comparing to the ballistic stretching movements. As a conclusion, they do not recommend SS prior to athletic performances with high level of forces. However, they recommended ballistic stretching because of the lower possibility of decreased maximal strength.

Another ballistic and SS study also done by Woolstenhulme et al., (2006) to investigate the effect of four diverse warm up routines preceded by 20-minutes of basketball game in vertical jump heights and flexibility. The interventions were the ballistic stretching, SS, sprints, or basketball shoots (control session) following six weeks (2 times for each week) of warm up and basketball game by the athletes. They measured sit-and-reach and vertical jump heights prior to (week-1) and following (week-7) the 6 weeks. They found increase in flexibility in the ballistic, static, and sprinting group comparing to the control session ($p < 0.0001$), but vertical jump heights did not vary in none of the groups. They stated that barely the ballistic stretching group reached acute increases in vertical jumps 20-minutes following the basketball game ($p < 0.05$). Because of a general acceptance that this type of stretching is not considered useful and can lead to injury but according to the result of this study, they recommend it and state that coaches and athletes may think utilizing ballistic stretching as a warm up in basketball game, since it is useful to vertical jump performances.

There appears to be very little clear evidence to suggest that one type of stretching protocol is beneficial for the athletic performance. A study performed by Samuel et al., (2008), did not find a significant effect on vertical jump, or torque outcome in the quadriceps and hamstrings but found decrease in lower-extremity power. Samuel et al., (2008) studied the effect of the length of acute static and ballistic stretching (BS) on vertical jumps (VJ), lower extremity power, and quadriceps and hamstring torques. They hired 24 participants for a 5 minute warm up preceded by one of the 3 conditions on different days with counterbalance design: SS, BS, or no stretching (control condition). The researchers suggested that SS and BS did not influence VJ, or torque outcomes in the quadriceps and hamstrings. They also found a surprising result that stretching decreased lower-extremity power. As a conclusion, because of the conflicting results, they recommend that trainers and athletes might use DS prior to power activities which were constantly recommended by the previous research.

2.7 Duration of Stretching

The review of literature again reveals different findings concerning the duration of stretching protocols which would create acute effects on the performance. Costa et al., (2009) studied the effect of various lengths of SS in dynamic balance. They tested 28 participants prior to and following 2 stretching protocols and a control session in 3 different days. The subjects held the stretching at the top of gentle discomforts and repeating 3 times with 15-seconds between each stretching. Subjects kept the positions for 15- or 45-seconds. The control session required a 26-minutes resting time between pre-test and post-test. Following the testing, they found that the 15-seconds protocol created significant improvements in the balance score ($p < .01$), with no significantly affected control condition or the 45-seconds intervention. In conclusion, they sum up that the duration for stretching routine of 45-seconds holding does not negatively influence balance as applying the current testing procedure. However, the stretching for 15-seconds holding might develop balance performances. Finally, the researchers recommended applying shorter duration stretching routines whenever targeting to advance balance performances. Consistent with this result, we, as well, used 15-second hold for our stretching protocols in our study.

Another study carried out by Matsuo et al., (2013) on muscle function and flexibility following different stretching durations to investigate the effect of different stretch periods and this study provided an insight into the best duration of SS. They hired twenty-four university students who did stretching of their right hamstrings for periods of 20, 60, 180, and 300-seconds in a randomly ordered design. These measurements were carried out; static passive torques (SPT), dynamic passive torques (DPT), stiffness, straight leg raises

(SLR), and isometric muscle forces. After the testing, they found that static passive torque was significantly lowered following all the stretching periods ($p < .05$). When looked into post hoc test, it was seen that static passive torque was significantly decreased following 60, 180, and 300-seconds of stretching comparing to the one after 20-seconds stretching. They also found significant decreased stiffness following 180 and 300-seconds stretching ($p < .05$). Additionally, DPT and stiffness were significantly lesser following 300-seconds than after 20-seconds stretching ($p < .05$). The SLR improved significantly following all stretching periods ($p < .05$). Isometric muscle force significantly decreased after all stretching durations ($p < .05$). As a result, their results showed that higher durations of stretching are related to a decline in SPT but an increase in SLR. To make a conclusion on the durations of stretching is that prolonged periods of stretching are required to cause superior flexibility.

There have been many studies looking at the effects of 15-second duration of the stretching on performance outcomes. Knudson et al., (2001) hired 10 males and10 females (mean = 23.7 yrs) and applied 3-reps x 15-second, 3 lower body stretches. They found that 55% of participants reduced jump velocity and 35% of participants improved jump velocity. Moreover, Robbins and Scheuermann (2008) acquired 20 males (mean = 20.3 yrs) for jumping performance. The protocol included 2, 4, or 6-reps x 15-second (15-second rest) for quads, hamstrings, and plantarflexors. They revealed a decline in squat jump heights after post 6-reps and no changes in SJ after post-2-reps or post-4-reps. Another same duration study (15-second) was used in the study of Young and Elliott (2001). They hired 14 males (mean = 22 yrs) to perform 3-reps x 15-second (20-second rest) 3 lower body stretches. After the testing, they found no changes in squat jumps performances but found decline in drop jumps performances. Kokkonen et al., (1998) also used 15-second stretching with 15 males and 15 females (mean = 22 yrs) to measure their 1RM. The subjects performed 6-reps x 15-second (15-second rest) 5 lower body stretches. The researchers found 7.3% decrease in 1RM knee flexion and 8.1% decrease in 1RM knee extension.

A different result was found in a study by Knudson et al., (2004). There were no changes in serve speeds or accuracy in the study on 83 tennis players with various skill levels. The protocol was created by 2-reps x 15-second (10-second rest) for 7 upper and lower body stretches. In another study, there was also no change after 15-second stretching. Unick et al., (2005) hired basketball players (mean = 19.2 years) to perform 4 lower body stretches with 3-reps x 15-second. They found no changes in CMJ heights and no changes in drop jump heights. On the contrary to the previous study, Faigenbaum et al., (2005) found reduced performances in shuttle run and reduced performances in long jumps in 60 children (mean = 11.3 yrs). The protocol was created with 2-reps x 15-second (5-second rest) for 6 lower body stretches

2.8 Static Vs Dynamic Stretching

Two ways of stretching that are generally used by athletes are static and DS. SS is the one while a position is hold for a chosen period at the ending position of the ROM with small or no movements and with maximal controlling (Alter, 2004). However, DS is actively stirring throughout a joint's whole ROM (Fletcher & Jones, 2004). DS also includes sport-specific exercises, therefore letting for proper ROM for the physical activities (Baechle & Earle, 2000). The effects of static and DS on performance outcomes were intended to be compared here with the related literature.

In the study of Herman and Smith (2008), the effect of stretching routines on the performances of wrestlers was investigated. This study is one of the few studies investigated on the wrestlers, as we did. Herman and Smith (2008) performed this research to establish if a DS warm-up (DWU) protocol executed every day more than 4-weeks positively affected the measures of power, speed, agility, endurance, flexibility, and strength performances in college wrestlers when comparing to a SS warm up (SWU) protocol. They hired 24 wrestlers allocated randomly to either a 4 weeks treatment session (DWU) (n =

11) or an active control session (SWU) (n = 13) prior to their everyday exercises. Their study involved assessments like, maximal torque of the quadriceps and hamstrings, medicine ball throws, 300-yd shuttles, pull-up, push-up, sit-up, broad jumps, 600-m runs, sit and reach test, and trunk extension tests. After testing, they found several performance improvements, as well as increase in quadriceps peak torques (11%), broad jumps (4%), underhand medicine ball throws (4%), sit ups (11%), and pushups (3%) after DWU. They state that the decreases in the average time to completing the 300-yd shuttle (-2%) and the 600-meters run (-2.4%) was indicative of improved endurances, agility, muscle strength, and anaerobic capacities in the DWU group. Contrary to the DWU protocol, they did not observe any improvements in the SWU protocol in the measures of performances. The researchers recommend that inclusion of the particular 4-weeks DWU protocol into the everyday exercise procedures of wrestlers created longer term or continued power, strength, muscle endurances, anaerobic capacities, and improvements in agility performances.

Another large scale study on power, flexibility and sprinting ability were carried out by Paradisis et al., (2014) to search the effect of static stretching (SS) and Dynamic stretching (DS) in flexibility, sprint ability and explosive powers of adolescent participants. They hired 47 mix gender adolescent participants to be measured following SS and DS of 40-seconds in quadriceps, hamstrings, hip extensors, and plantar flexors. They looked into the effect of stretching on 20-meter sprint running, countermovement jump (CMJ) heights, and sit-and-reach flexibility test. As a result, they found that SS affected 20-meter and CMJ in the participants in negative way by 2.5 and 6.3%, respectively. They presented no effects in 20-meter in participants following DS but damaged CMJ by 2.2%. On the other hand, they revealed that both SS and DS enhanced performances in flexibility with SS tending to be extra useful (12.1%) comparing to the DS (6.5%). According to these results, they concluded SS significantly impairs sprint performances and explosive powers in the participants, while DS reduce explosive power values and has no impact in sprint performances. With these in mind, the type of stretching utilized in the adolescents must be chosen very carefully and be specific to some tasks because they did not react similar to the most of the literature covered here according to this study.

In a study carried out by Papadopoulos, Siatras & Kellis (2005) to investigate the effects of SS and DS movements on maximum isokinetic torque of knee extensors and flexors muscles. They hired 32 participants between the ages of 19-22 years to complete 3 diverse routines involving A) warm up, B) warm up and SS and C) warm up and DS movements, on 3 nonconsecutive days. The protocol involved the measurement of the knee extensors and flexor muscles maximal concentric torque on an isokinetic dynamometer at 60 and 180°/s. They found significantly differed maximal torque after the diverse protocols. They presented a decreased torque in knee extensors $p<0.01$) and knee flexor muscles ($p<0.01$) at both velocity following SS routine. They conclude that the results point out the negative influences of the SS movements on maximum isokinetic torque productions, as DS does not seem to have any restrictive effects.

Again, power and peak torque in elite soccer players were measured by Arent (2010) evaluate the effect of SS and DS lower-body stretching routines on vertical jumps and knee extensions and flexion peak torque in elite athletes. The protocol started with a 5-min general warm up and after that the stretching routines endured around 15-min and focused on the lower body. Following the stretching, participants applied the countermovement vertical jumps in 2 efforts with no arm swing (CMVJ) and knee extensions and flexions with their leading leg at 180 degrees. They found greater performance increase after DS for CMVJ ($p = .001$), maximal torque at 180 degrees and flexions ($p = .03$) comparing to the SS. DS revealed significantly better VJ heights and peak torques for knee extensions and flexions in the football players. They conclude that SS in a warm up is not a useful way to develop performances in elite football players. As an alternative, trainers and athletes might think performing DS as part of their warm up routine to lead to improved performances in exercises related to better successes in football.

Agility is an important factor for many sports, especially for wrestling. In an agility study, Troumbley (2010) investigated the effects of static and DS on explosive agility exercises. Twenty-four participants were joined for the various warm up routines, involving no warm up (NWU), static stretching (SS), dynamic stretching (DS), and DS with SS (DS+SS). As in our study, the T-Drill was selected to measure agility. The results showed that there was significantly differed scores in the NWU and DS conditions (effect size =0.45, p =0.03), the SS and DS conditions (effect size =0.85, p<0.001), and the DS and DS+SS conditions (effect size=0.40, p =0.03). These results presented that DS revealed the fastest agility test time and SS produced the slowest agility times. The data shows that the advantages of DS might have been weakened when preceded by SS. Consistent with the previous studies, this researcher also does not suggest SS prior to agility, because of the harmful effects on the stretch shortening cycles, and agility.

In recent agility study, Bafghi and Khorasani (2013) investigated enduring effects of SS, DS and no-stretching methods in agility in collegian soccer players. They hired fifteen collegiate soccer players (age: 24.73 ± 4.59 years) for agility performances employing the Illinois agility test following the warm-up completion and at 15 minutes later. They stated that the findings showed significant differences in agility time as compare to static and no-stretching methods. There was no significant difference in the first and second posttests after dynamic, static and no stretching methods. Like the previous study, they also proposed that collegian soccer players most likely achieve better agility scores after DS as compare to SS. Similar recommendation made by Chaouachi et al., (2010) after they studied the effect of SS and DS in agility performances. The control session (4.2±0.15 seconds) revealed significant difference (p = 0.05) at faster times than the DS + SS plus stretching to the point of discomfort (4.28s ±0.17) session in the 30-meter sprint. According to these results, they suggested that elite athletes who like to apply SS might involve an sufficient warm up and dynamic sport specific movements with at least 5 or more minutes of recovery time prior to their athletic event.

DS helps to recover the side effects of SS when they are performed together according to the literature. In another study, soccer players were tested by Amiri-Khorasani (2010) to investigate the effect of SS, DS, and the mixture of static and DS within a pre exercise warm up in the Illinois agility test (IAT). They hired 19 elite football players (age=22.5±2.5 years) for agility performances employing the IAT following the various warm up routines involving the SS, DS, combined stretching, and no-stretching. Following the testing, they found that there was a significant decrease in agility times following no-stretching, in no-stretching vs. SS; following DS, among static vs. dynamic stretching; and after DS, among dynamic vs. combined stretching during warm-ups for the agility. There was significant decreases in agility times following DS vs. SS in less and more experienced athletes. SS does not show to be disadvantageous for agility performances when united with dynamic warm up for the athletes. However, DS in the warm up was the most useful as training in agility performances. They conclude that more qualified athletes reveal improved agility skill.

It can be seen from the above conclusion that elite and experienced athletes show better performance outcomes especially in agility. A study on professional soccer players carried out by Gelen (2010), the effect of various warm ups on football performances was studied. In the study, 26 elite football players (23.3±3.2 years) executed 4 diverse warm up routines in randomly ordered design on non-consecutive days. The procedure included 5-minutes of jogs (Method A), 5-minutes of jogs and SS (Method B), 5-minutes of jogs and dynamic exercise (Method C), and 5-minutes of jogs and a mixture of SS and dynamic exercise (Method D). The testing included the sprints, slalom dribbles, and penalty kicking performances. The researcher presented significantly decreased sprinting, slalom dribbling, and penalty kicking performance following Method C when comparing to Method A ($p < 0.05$). They did not find a significant difference in sprints, slalom dribbles, and penalty kicking performance in Method D when compared with Method A ($p > 0.05$). Similar findings with the earlier research that the researcher recommends dynamic exercises before the high power output exercise activities.

A different perspective in a recent study carried out by Winchester et al., (2008) to figure out if the harmful effect of static stretching (SS) would clear the improvements in performances gained from the dynamic warm up (DW). They hired 22 athletes to apply a DW preceded with a SS or resting (NS) protocol. According to the results, they state that times for the NS opposed to the SS protocol was considerably shorter in the second 20-meter by a time of 2.41 vs. 2.38 seconds ($P \leq .05$), and in the whole 40-meter by a time of 5.6±0.4 vs. 5.7±0.4 seconds ($P \leq .05$). The findings of this research recommend that employing a SS routine after a DW would hold down the sprint performances in college athletes. Also, in a diverse study, Fletcher and Monte (2010) investigated the effects of various warm up models in particular motor skills related to football performances. They hired 27 soccer players for three warm up protocols, active warm up (WU), WU with static stretching (SPS), and WU with dynamic stretching (ADS). The tests included heart-rate, countermovement jumps, 20-meter sprints, and Balsom agility test following every protocol. They found that vertical jump height was considerably greater ($p < 0.01$) in the WU and ADS protocols comparing to those in the SPS protocol. They also found slower SPS condition ($p < 0.01$) in the 20-meter sprints and agility scores than the WU and ADS protocols. Besides, they presented significantly higher heart rate ($p<0.01$) for the post WU and ADS trials of athletes comparing to the SPS protocol. They also finally recommended specific dynamic stretches for optimal performance in a warm up, instead of the usual SS.

Van Gelder et al., (2011) investigated the effects of SS and DS in performance times of athletic agility tests. They hired 60 participants involving college (n=18) and leisure (n=42) basketball players. The participants were assigned randomly to 1 of 3 protocol groups; NS, DS or SS. Each group finished a 10-minutes warm up jogging preceded by a 3-minutes resting. The SS and DS groups then finished an 8.5-minutes stretching protocol. Consistent with the previous studies, the DS group performed considerably shorter times in the agility tests (2.22±0.12 seconds) when compared to the SS (2.33±0.15 second, $p=0.013$) and NS group (2.32±0.12 second, $p=0.026$). The researchers conclude, according to the results, that DS develops performances on closed agility skills including 180° changes of directions in comparing to SS or NS.

In a comprehensive study, Dimitris et al., (2014) compared the acute effect of 3 diverse stretching routines in balance, agility, reaction times and movement times of the upper limbs. Subjects were 31 women athletes (age = 17.3±0.5 yr.). Each subject executed one of the protocols on a separate day: (a) 3-minute jog preceded by a 7-min SS (b) 3-min jog preceded by 7-min DS, and (c) 3-min jog proceeded by 7-min of rest (NS). Following the protocol, subjects carried out the next tests: dynamic balance, 505 agility test, reaction times, and movement times. The orders of stretching routines and tests of performances were made by counterbalancing to prevent after-effects. The significance was reached in main effects for each variable with the exception of reaction times. The DS group comparing to SS carried out considerably superior in balance, agility and movement times. In addition, the DS group comparing to NS carried out significantly superior in agility. With respect to the findings of this research, a DS routine is more suitable than SS in movements that necessitate balance, quick running direction changes (agility) and movement times of the upper extremity.

One of the few reaction times study also carried out by Perrier, Pavol and Hoffman (2011) to investigate the effect of a warm up with SS vs. DS in reaction times, countermovement jump (CMJ) heights, and low back and hamstring flexibilities. They hired 21 participants (24.4±4.5 years). The protocol involved a 5-minutes treadmill jogging preceded by one of the stretching treatment: no-stretching (NS), SS, or DS. The tests involved a sit-and-reach test, a sequence of 10 maximal effort CMJs, and reaction times detected from assessed ground reaction forces. They found that the height in CMJ was superior for DS (43.0 cm) than for NS (41.4 cm) and SS (41.9 cm). Jump heights declined from the initial to the later jumps. They also did not find a significant effect of treatment in reaction time. They revealed significant effect ($p < 0.001$) in flexibility following SS and DS comparing to the after NS, with no differences on flexibility in SS and DS which are similar results with our study. They also recommended DS for Athletes who wants to improve lower-extremity power in warm up to improve flexibility as enhancing performances.

Strength is one of the crucial aspects of many athletic performances. The studies on strength, torque, power and flexibility (ROM) were the main concern of this part of literature review. Herda et al., (2008) examined the effect of SS vs. DS on Peak torque (PT) and electromyographic (EMG) in maximal contraction of the leg flexor at 4 knee joint angles. They hired 14 men (25±4 years) to execute 2 maximal leg flexions at knee joint angles of 41°, 61°, 81°, and 101° under complete leg extensions. The protocol involved 4 repetition of 3 SS movements kept for 30-seconds each and consisted of 4 sets of 3 DS movements carried out (12-15 repetition) with each set continuing 30-seconds. They found declined PT following the SS at 81° ($p = 0.019$) and 101° ($p = 0.001$). They did not find significant changes in PT ($p > 0.05$) following the DS. They also state that EMG amplitude stayed unaffected following the SS ($p > 0.05$) though, improved following the DS at 101° ($p < 0.001$) and 81° ($p < 0.001$). According to the data, they recommended that the declines in strength following the SS might be the effect of mechanical other than neural mechanism in the BF muscles. In conclusion, the researchers reveal that a DS routine might have fewer disadvantageous to muscles strength than SS in the hamstrings.

In a strength study, Beedle et al., (2008) studied to find out if the significance could be reached in SS, DS, and no stretching (NS) in maximum strength in nineteen college aged men and 32 women. The participants had prior weight training experiences. They found no considerable differences following any of the treatment. Moderate intensity stretching may not negatively influence 1RM in the bench and leg presses. In addition, elite athletes were tested in a study with another positive strength outcome following DS carried out by Sekir et al., (2010) to investigate the effects of SS and DS of the leg flexor and extensor on peak torque (PT). They hired 10 elite female athletes for the measurements in a random order design on different days: (a) no-stretching (control), (b) SS and (c) DS. They measured the quadriceps and hamstring muscle groups. They found consistent findings with the literature that the strength of the quadriceps and hamstrings muscles in the test speeds revealed significantly decreased values following SS ($P<0.01$–0.001). On the other hand, they found a significant increase following DS for the strength variables ($P<0.05$–0.001). They recommend that DS might be a better method for improving muscle performances in the pre competition warm up in elite women athletes.

Certainly, there is no shortage of agreement within the literature on the benefits of DS in the performance outcomes of athletes. In another example, Torres et al., (2008) investigated the influences of upper body SS and DS on upper body muscle performances. They hired 11 elite male athletes (19.6±1.7 years). Subjects carried out 4 stretching routines (no-stretching, SS, DS, and combined SS and DS) preceded by 4 tests: 30% of 1 RM bench throws, isometric bench presses, overhead medicine ball throws, and lateral medicine ball throws. Following the testing stages, they found no significant difference in stretching tests for maximal power and forces. They also did not find any differences in stretching tests for maximal velocities or peak displacements for the medicine ball throws. In terms of the lateral medicine ball throws, they did not record any differences in maximal velocity in stretching trials, too. On the other hand, they found significant maximal displacements ($p \leq 0.05$) for the SS and DS conditions comparing to the static only protocol. As a conclusion, they reveal that they did not detect any short term effects of SS or DS on upper body muscle performances in adolescent male athletes irrespective of stretching modes. They also suggest athletes performing in the field sports might carry out upper body stretching, because the performance in throws was mainly unaltered by SS or DS of upper body movements. In a consistent way with the previous literature, this researcher, too, suggested a dynamic warm up for the whole warm up section.

Sprinting is also a power based activity and it has been on the centre of many studies in the sports science. In this recent study, Sim et al., (2009) to researched the effect of SS in warm up on sprint performances and also to evaluate any influences of the orders in which DS movements (i.e., run-through) and SS are applied. They acquired 13 elite athletes for sprinting ability tests including three sets of maximum 6 × 20-meter sprinting after executing one of 3 warm up routines in a within subjects counterbalancing study. The protocol involved warm up routines with a first 1000-meter jogging preceded by dynamic activity only (D), SS preceded by dynamic activity (S-D), or dynamic activity preceded by SS (D-S). After the testing phase, the researcher did not find consistent significant differences in tests for 20-meter sprint records. They also found that no significant difference or large effects sizes were recorded in D and S-D, demonstrating similar performances in repeated sprint abilities. In conclusion, they sum up that those findings display that 20-meter repetitive sprint ability might be affected negatively once SS is carried out following DS and instantly preceding performances (D-S).

There was a recent comprehensive study carried out to determine many aspects of performance in soccer players, such as, power, flexibility, sprint performances and repetitive sprint ability. In this research, Turki et al., (2014) analyzed the effect of 8 weeks of warm ups combining 2 DS routines: active DS (ADS), static DS (SDS) in squat jumps (SJ), countermovement jumps (CMJ), 20-meter sprint performances and repetitive sprint abilities (RSA) and hip ROMs in 37 elite athletes. Following the testing phase, they found that SJ height, CMJ height, CMJ force and CMJ peak power improved significantly after static DS (SDS) and active DS (ADS) exercise when comparing to the control measurement. However, they did not find any effect on the sprint performances or RSA by either of the DS exercise routines. The exercise routines of SDS and ADS created parallel enhancement in flexibility comparing to the non significant alterations in the control group. Overall, they concluded that the involving ADS and SDS in standard warm up of an 8-weeks exercise program might develop flexibility and also jump power outcomes.

The researches, like the previous one by Turki et al., (2014), did reveal consistent, significant indications that SS has tendency to lower the various performance outcomes whereas DS has tendency to improve the same outcomes according to the literature. In a study examining the sprint time and musculotendinous unit (MTU) stiffness, Fletcher and

Anness (2007) studied the effects of applying the SS and DS factors related to a conventional track and field warm up. They hired 18 elite runners for repeated measures with 3 protocols: active DS (ADS), static passive stretching joint with ADS (SADS), and static dynamic stretch joint with ADS (DADS). The protocol involved a standard 800-meter jogging warm up prior to the stretching interventions, preceded by two 50-meter sprints. After the testing phase, they found that the SADS protocol produced significant ($p <= 0.05$) slower 50-meter sprinting scores then the ADS or DADS protocol. They also found a decline in sprint times monitored following the ADS protocol comparing to the DADS protocol. The researcher relates this decline in performances post SADS protocol with a decline in the musculotendinous unit (MTU) stiffness. As a conclusion, they stated that passive SS in a warm up decrease sprint performances, even though being united with DS, when comparing to an exclusively DS concept.

CHAPTER 3

METHODS

The purpose of this study was to examine and compare effects of static (SS) and dynamic stretching (DS) on power, agility and flexibility in elite wrestlers.

3.1 Participants

The study involved 34 elite male wrestlers (18-25 years) volunteered to participate in the study (age=20.09 ± 2.00 years). The participants were all competing at the national level championships in Turkey and were free from any injury for the last 6 months (i.e., ankle or knee injuries). The wrestlers were the members of different wrestling clubs located in Ankara. They were previously familiar with the stretching techniques that were used in the tests in their daily workouts. Prior to participating, each individual completed an informed consent form approved by the Middle East Technical University Ethical Committee, which included the purpose of the study and the right to remove himself from the testing whenever they like with no question (Appendix A). The names of the participants were not recorded.

In order to be accepted into the study, a participant needed to meet the following inclusion criteria:

1. Be over 18 years of age.
2. Be among the national level wrestlers competing in the national championships in Turkey.
3. Be physically injury free for the last 6 months.

3.2 Research Design

To determine the effects of static (SS) and dynamic stretching (DS) in power, agility and flexibility in elite wrestlers, a within subject experimental design was used. The participant performed Standing long jump, T-Test and Sit and reach test on three separate days under three conditions: no stretch, dynamic stretch and static stretch. The independent variable was the stretching type with three levels (dynamic stretching, static stretching and no stretching). The dependent variables were the power, agility and flexibility.

Table 3.1 Study Design

PROTOCOLS	**No Stretching (NS)**			**Dynamic Stretching (DS)**			**Static Stretching (SS)**		
Test Days	1. Day	2. Day	3. Day	1. Day	2. Day	3. Day	1. Day	2. Day	3. Day
Jogging (5 min)		+	+	+	+	+	+	+	+
Stretching (10 min)				+	+	+	+	+	+
Power	+			+			+		
Agility		+			+			+	
Flexibility			+			+			+

Note: Standing Long Jump was used for power, T-Drill was used for agility, Sit and Reach Test was used for flexibility

3.3 Data Collection Procedures

This study was approved by the Human Research Ethics Committee at the Middle East Technical University (Appendix B). Before testing, the subjects were gathered in a training center and were explained the details of the study. In the meeting, the Informed Consent Forms (Appendix A) were read and signed by the subjects. The procedures were explained, and the risks involved were mentioned. The subjects were familiar with the stretching protocols to be used in the study and they were motivated verbally during the tests. Each subject was individually tested at nine different times (three times for each independent variable). There were at least 24 hours between each testing. The participant did not know which stretching protocol they would perform. The design was a single-blind controlled study. DS and SS interventions were performed randomly.

All treatments began with a five minute warm-up (Curry et al., 2009; Tsolakis, 2012, Zimmer et al., 2007) by a light jogging. For the baseline measurements, following the 1-min rest period after warm-up, the participants performed one of the tests (Standing long jump, T-Drill and Sit and reach test) on three consecutive days. The participant performing DS and SS protocols began their stretching treatment following after warm-up period that lasted approximately 10 minutes. The researcher kept a timer and list of stretches that would be performed to inform the subject when to switch stretches, to make sure that each subject was applying stretches for the same duration and that rest periods were consistent. There was 1-min rest period between trials (Bradley, P.S., Olsen, P.D., and Portas, M.D., 2007 & McMillan, 2006).

All efforts were given to limit potential confounding variables. Such as, tests were performed at the same time each day. The subjects were informed not to eat or drink anything other than their regular meal. The subjects were questioned for injury, sickness, or extreme fatigue every day before the tests. In addition, they were informed about the importance of their best effort every day prior to testing.

3.4 Dynamic Stretching

The DS protocol (Appendix E) consisted of high knees (gluteals and hamstrings), lateral lunges (inner thighs), lateral shuffles (adductors & abductors), crossovers (adductors & abductors), crossovers leg swings (adductors & abductors), and heel to toe walks (gastrocnemious & soleus), skips (hip flexors, gluteals, quariceps). Each stretch was held twice for 15 seconds bilaterally (McMillian, Moore, Hatler, Taylor, 2006; Bishop & Middleton, 2013; Fletcher, 2004). Total stretching duration was 210 seconds.

3.5 Static Stretching

Static Stretching involves a slow, deliberate movement that can be sustained for a period of 10 to 30 seconds to train the neuromuscular responses of the sensory receptors within the muscle (Kaminsky, et al., 2006). The static stretching protocol (Appendix D) consisted of a quadriceps stretch, abductor stretch, hip flexor stretch, adductor stretch, hamstring stretch, gluteal stretch, and the gastrocnemious/soleus stretch. Each stretch was held twice for 15 seconds bilaterally (McMillian, Moore, Hatler, Taylor, 2006; Bishop & Middleton, 2013; Fletcher, 2004). Total stretching duration was 210 seconds.

3.6 Power Testing - Standing Long Jump

This test measures the explosive power of the legs. The researcher kept a tape measure to measure distance jumped, non-slip floor for takeoff and landing were provided. The takeoff line was clearly marked to be seen by the participants. The participants stood behind the line marked on the ground with feet slightly apart. A two foot take-off and landing was performed, arm swinging and the knee bending were needed to provide forward drive. The subjects try to jump as far as possible and they must land on both feet without falling backwards (Figure 3.1). The measurement of the distance was taken from take-off line to the nearest point of contact on the landing (back of the heels). Longest distance jump was chosen from the best of two attempts.

The standing long jump test was chosen as a field test to measure the differences in power after the stretching protocols. The standing long jump has been used widely as a test of lower body muscular strength, power, and explosive strength (Pate, Oria, & Pillsbury, 2012). Moreover, the standing long jump correlates strongly (r = 0.70-0.91) with other field-based power tests (i.e., vertical jump & countermovement vertical jump) (Castro-Pinero et al., 2010). It also showed to have moderate to high reliability in youth (r = 0.52-0.99) (Benefice et al., 1999; Malina et al., 2004). It presents moderate to strong correlations with isokinetic quadriceps torque (r = 0.50) (Holm et al., 2008) and total-body isometric strength (r = 0.77) (Castro-Piñero et al., 2010). Horizontal jumping ability test may be a better protocol than vertical jump test when measuring the progress in power and observing performance progress for power oriented athletic events (Castro-Piñero et al., 2010).. Similarly, standing long jump tests seem to be the most valid field-based muscular fitness tests when compared to isokinetic strength (Artero, 2012).

The following equation was used for finding Peak Power.
Peak Power (W) = 60.7 × (jump height [cm]) + 45.3 × (body mass [kg]) − 2055. (Sayers et al., 1999).

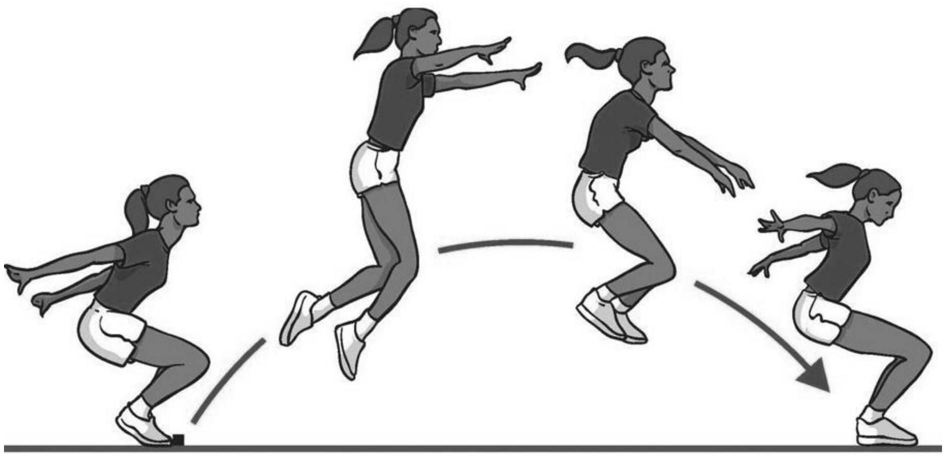

Figure 3.1 Standing Long Jump

*Standing Long Jump (*1999). Retrieved November 01, 2014, from http://www.westmerciasupplies.co.uk/media/catalog/product/cache/5/image/9df78eab33525d08d6e5fb8d27136e95/700002cx_1.jpg

3.7 Agility Testing - T-Drill

The T-Drill was used to measure agility. The T-test for agility is a valid and reliable test to measure agility requiring the athlete to sprint forward, laterally, and backward as quickly as possible (Pauole, 2000). The T-Drill was chosen for testing agility for the reason of the vigorous characteristics of wrestling. Wrestling involves basics of speed, rapid changing of path, explosive movements. In T-Drill, 3 cones (A, B, C) were placed 5 meters separate on a direct line by the researcher and the cone (A) is located 10 meters from the center cone (B) in order that the 4 of them shape a 'T' (Figure 3.2). The subject begins running from cone (A) and contact the center cone (B), shuffles to left side to cone (C) to contact, and then shuffles to the cone (D) to touch, then shuffles back to the center cone (B) and contacts it and then sprint 10 meters backward and contacts the cone (A). T-Drill times were recorded with an automated timer (Newtest Powertimer Systems, Finland). Timing of the trials began and finishes as soon as the subject penetrates the laser light beam on the start/stop line. Times were recorded to the nearest 0.1 seconds; they were given a five-minute rest interval, and asked to repeat the test again. The T-Drill run was performed twice and the best of the two trials was taken as subject's record.

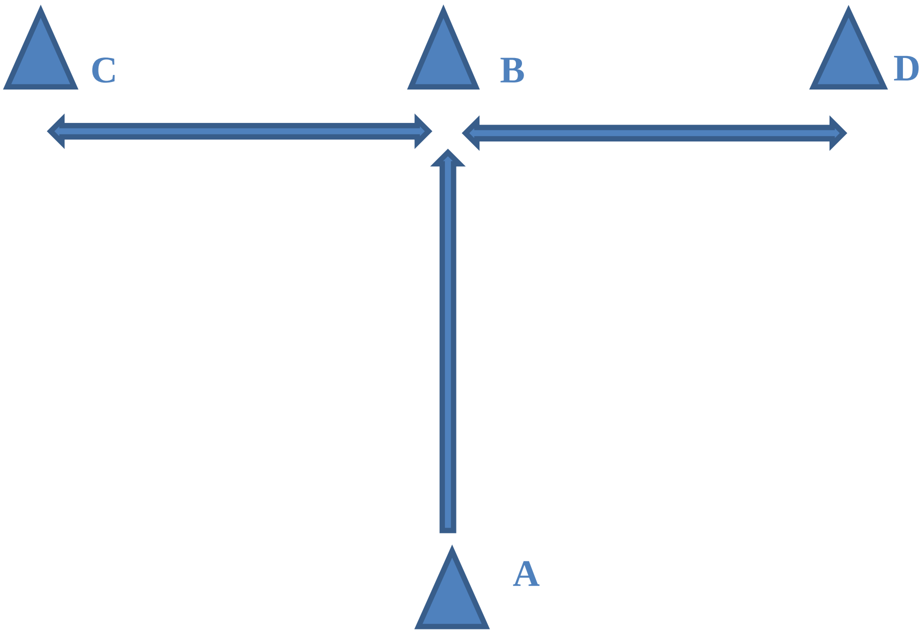

Figure 3.2 T-Drill Agility Test

3.8 Flexibility Testing - Sit and Reach Test

The standard sit-and-reach test was chosen to measure hamstring flexibility (Wells, 1952). This test is now extensively utilized as a common experiment of flexibility and deemed reliable for measuring flexibility of the hamstring (Baechle & Earle, 2000, Chung & Yuen 1999). A standard sit & reach box was utilized for testing flexibility to the nearest centimeter (Wells, 1952). The wood box has dimensions of 30,5 cm x 30,5 cm x 30,5 cm, with an extension of 23 cm for the support of the upper limbs of the subjects. During the tests, the researcher controlled to make sure that the heel stayed at the 23 cm reference point. Over the box and the extension, there is a metric scale of 50 cm that allows determining how far the individual can reach. On the standard Box, during the test, participants' feet soles are at the 23 (twenty-third) cm of the metric tape (Figure 3.3).

The subjects were requested to take off their shoes and be seated with legs fully lengthened before them with their feet flat alongside the box. Subjects were informed to put one of their hands over their other hand and extend forward as reaching hands towards the end of the box till they could no more reach forward. The researcher records the distance reached by the athlete’s finger tips (cm). The ultimate distance was kept for 2 seconds. The best of two trials were recorded as the subject’s best score.

Figure 3.3 Sit and Reach Test

Sit and reachtest (1999). Retrieved November 01, 2014, from http://www.homeware.be/images/sitenreach.gif)

3.9 Statistical Analysis of Data

The data were analyzed with a repeated-measures analysis of variance (ANOVA) using the SPSS 17.0 for Windows statistical software. The subject attributes and investigational variables were considered as mean + SD in descriptive data. A bonferroni post-hoc test was run for significance on the treatment factor. Statistical significance was tested at $p = 0.05$.

CHAPTER 4

RESULTS

The purpose of this study was to examine the differences between three stretching protocols (dynamic stretching (DS), static stretching (SS) and no stretching (NS)) on the performance of the T-Drill for agility, Standing long jump for power and Sit and reach test for flexibility in elite wrestlers.

A total of 34 subjects [(mean ± SD) age, 20.1 ± 2.0 years; height, 171.0 ± 3.2 cm; weight, 75 ± 5.2 kg] completed this study. The demographic information is presented in Table 4.1.

Table 4.1 Study Participant Demographics

	N	*Min*	*Max*	*Mean*	*SD*
Subject Age (years)	34	18	25	20.09	2.00
Height (cm)	34	166	178	171	3.24
Weight (kg)	34	65	85	75	5.25
Years of Experience in Wrestling	34	5	14	8	2.29

All hypotheses were tested with the level of significance set at .05. Three separate repeated-measures ANOVA were used to test the main hypotheses regarding the relationship between the stretching protocols and their effects on the performance values of Agility, Power and Flexibility. Mean power, agility and flexibility were calculated under three test conditions (NS, DS, and SS). Paired comparisons were made to examine which pairs of means differed.

4.1. Power

Power was measured after standing long jump to test the first hypothesis (H_O1) that stretching types do not have a significant effect on power values of subjects. Before the analysis, the assumptions of repeated measures of ANOVA were checked as follows.

4.1.1 Assumptions

Normality Assumption:

Test of normality (The Shapiro-Wilk Test) results is provided in the Table 4.2 and the Q-Q plot (Figure 4.1) shows the distributions of power scores. The Shapiro-Wilk Test is suitable for small sample sizes (< 50 samples). According to the Table 4.2, the dependent variable was normally distributed. Value of the Shapiro-Wilk Test is greater than 0.05 ($p < .05$)

Table 4.2 Test of Normality for Power

	Shapiro-Wilk		
	Statistic	*df*	*p*
NS – Power	.950	34	.126
DS – Power	.948	34	.107
SS – Power	.954	34	.159

Note. NS = No Stretching, DS = Dynamic Stretching, SS = Static Stretching

Outliers:

For outliers, the boxplot (Figure 4.2) values were obtained to examine the distributions for the variables. Standing long jump scores following dynamic stretching contained 1 outlier (5) at the lower end of the scale with values of 13,316.7 W. After the case identified, outlier was removed from the sample, the distribution for power was examined again. No outliers were identified and the distribution appeared to be normal.

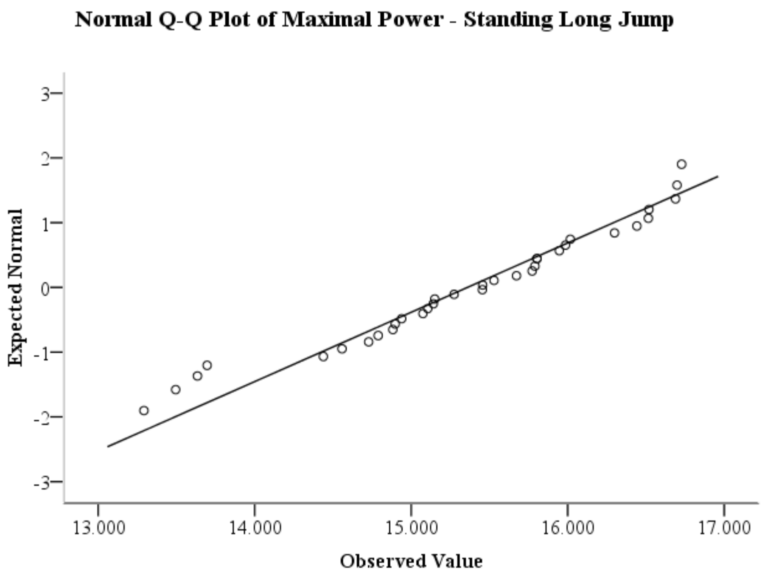

Figure 4.1 The distributions of power scores

Sphericity Assumption:

Mauchly's Test of Sphericity indicated that the assumption of sphericity had not been violated, $\chi^2\,(2) = .790$, $p = .674$.

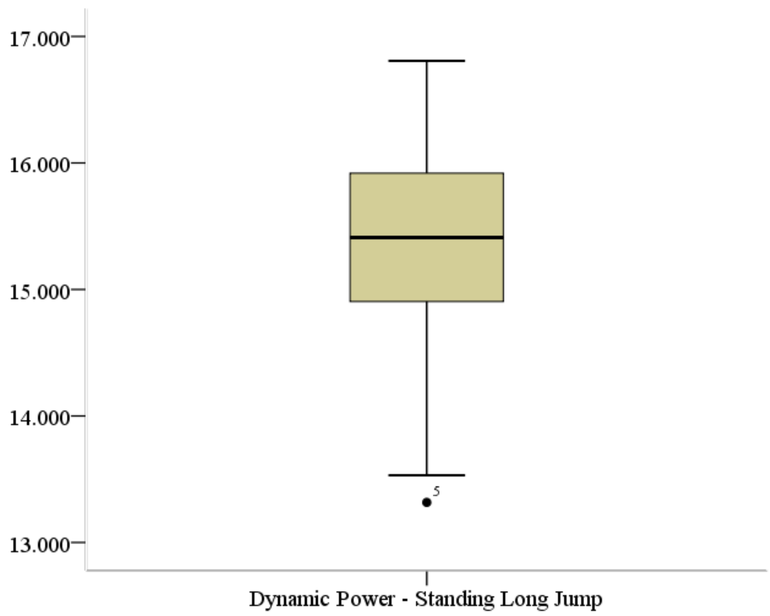

Figure 4.2 The outliers in the scores of Standing Long Jump following DS

4.1.2 Findings

After testing the assumptions of the repeated measures of ANOVA and observing that they were met, statistical analyze were conducted. A repeated measures ANOVA showed that, for the thirty-four subjects, the difference in power scores between the NS (*M* = 15,359.4, *SD* = 934.2), DS (*M* = 15,371.4, *SD* = 945.09) and SS (*M* = 15,370.3, *SD* = 961.2) were statistically not significant F (2, 66) = .376, $p > 0.05$). The repeated-measures analysis of variance revealed that the stretching conditions did not produce a significant increase in mean power output in elite wrestlers. Thus we accepted the first hypothesis (H_O1).

The athletes did yield better distance scores after the dynamic and static stretching protocols but it was not enough to be statistically significant. The means and standard deviations are presented in Table 4.3.

Table 4.3 Mean Power Output after Three Stretching Conditions

	N	*Min.*	*Max.*	*Mean*	*SD*
Power – NS (W)	34	13,292.4	16,727,7	15,359.4	934.2
Power – DS (W)	34	13,292.4	16,727.7	15,371.4	945.1
Power – SS (W)	34	13,334.9	16,789.8	15,370.3	961.2

Note. NS = No Stretching, DS = Dynamic Stretching, SS = Static Stretching

4.2 Agility

Agility was measured by T-Drill agility test to check the second hypothesis (H_O2) that stretching types does not have a significant effect on agility values of subjects. Before the analysis, the assumptions of repeated measures of ANOVA were checked as follows.

4.2.1 Assumptions

Normality Assumption

Test of normality (The Shapiro-Wilk Test) results is provided in the Table 4.4 and the Q-Q plot (Figure 4.4) shows the distributions of agility scores. According to the Table 4.4, the dependent variable was normally distributed. Value of the Shapiro-Wilk Test is greater than 0.05($p<.05$)

Table 4.4 Test of Normality for Agility

	Shapiro-Wilk		
	Statistic	df	p
NS – Agility (s)	.944	34	.083
DS – Agility (s)	.937	34	.056
SS - Agility (s)	.956	34	.181

Note. NS = No Stretching, DS = Dynamic Stretching, SS = Static Stretching

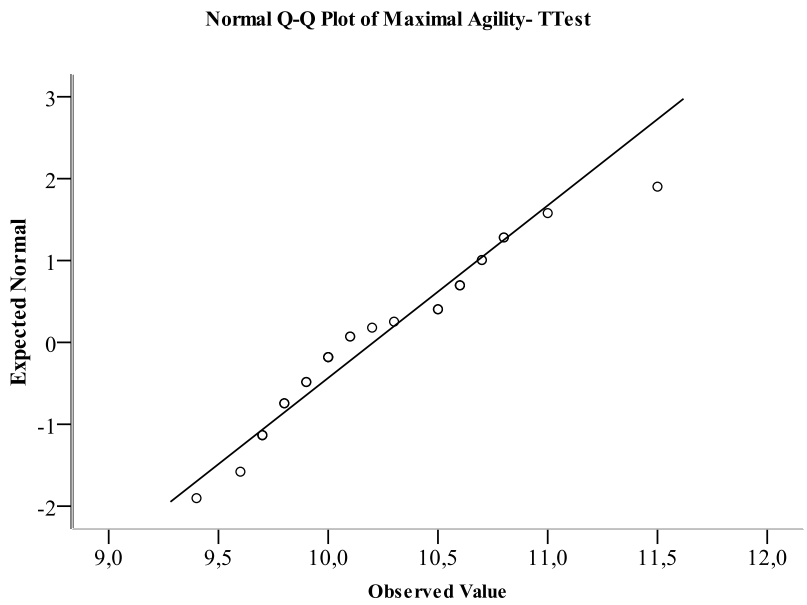

Figure 4.4 The distributions of agility scores

Outliers:

For outliers, the boxplots values were obtained to examine the distributions for the dependent variables. T-Drill (agility) values following dynamic stretching contained nine and seventeen two (9, 17) at the upper end of the scale with values of 11,7 and 11,3. After the cases identified, outliers were removed from the sample, the distribution for agility was examined again. No outliers were identified and the distribution appeared to be normal. The analysis was conducted without the outliers. Analyze concluded that there was significant difference between NS and SS, and DS and SS. Both p-values were below a significance level of .05.

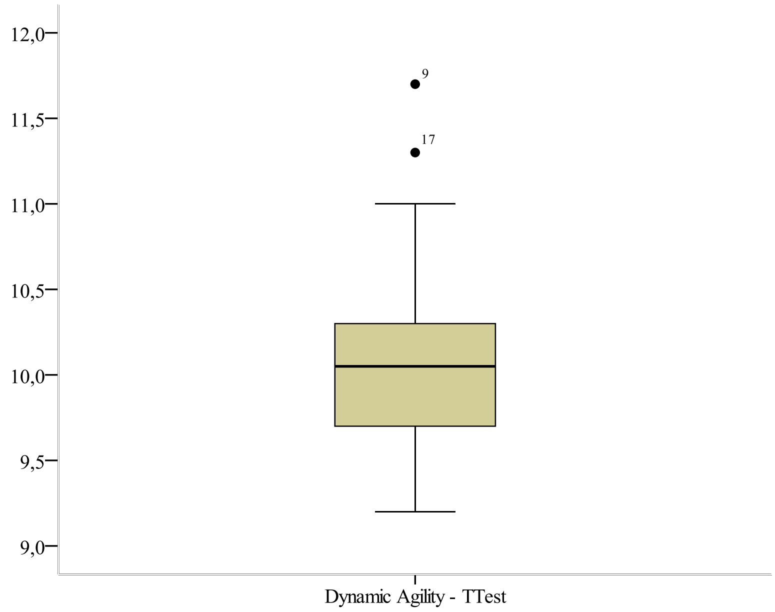

Figure 4.5 The outliers in the scores of T-Drill following Dynamic Stretching

Sphericity Assumption

Mauchly's test indicated that the assumption of sphericity had been violated χ^2 = 10.62, p<.005. Therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity.

4.2.2 Findings

After testing the assumptions of the repeated measures of ANOVA and observing that they were met, statistical analyze were conducted. Repeated measures ANOVA showed that there was a significant difference in agility scores after stretching protocols $F(1.559, 51.463) = 5.88$, $p < 0.05$), ($M = 10.206$, $SD = .474$), DS ($M = 10.094$, $SD = .547$) and SS ($M = 10.335$, $SD = .585$). Explained total variance was 15 % (partial $\eta 2 = 0.15$). Thus we accepted the second hypothesis (H_O2). The means and standard deviations are presented in Table 4.6.

Table 4.5 Mean Agility Output After Three Stretching Conditions

	N	*Min*	*Max.*	*Mean*	*SD*
Agility – NS (s)	34	9.4	11.5	10.21	.47
Agility – DS (s)	34	9.2	11.7	10.09	.55
Agility – SS (s)	34	9.4	11.9	10.34	.59

Note. NS = No Stretching, DS = Dynamic Stretching, SS = Static Stretching

To look at where those differences occurred, Bonferroni test was run to make pairwise comparisons and it indicated that significant differences were observed between NS and SS, and DS and SS ($p < .05$) but not in between NS and DS ($p > .05$) despite the increase in the test results of the agility after DS protocol but it was not enough to be statistically significant (Table 4.6).

Table 4.6 Pairwise Comparison Values of Protocols for Agility

Agility		*Mean Difference*	*p*
NS	DS	.112	.375
	SS	-.129*	.050
DS	SS	-.241*	.023

Note. NS = No Stretching, DS = Dynamic Stretching, SS = Static Stretching
a. Adjustment for multiple comparisons: Bonferroni.
*. The mean difference is significant at the .05 level.

4.3 Flexibility

Flexibility was measured after Sit and reach test to check the third hypothesis (H_O3) that stretching types does not have a significant effect on flexibility values of subjects. Before the analysis, the assumptions of repeated measures of ANOVA were checked as follows.

4.3.1 Assumptions

Normality Assumption

Test of normality (The Shapiro-Wilk Test) results is provided in the Table 4.7 and the Q-Q plot (Figure 4.7) shows the distributions of flexibility scores. According to the Table 4.7, the dependent variable was normally distributed. Value of the Shapiro-Wilk Test is greater than 0.05 ($p<.05$)

Table 4.7 Test of Normality for Flexibility

	Shapiro-Wilk		
	Statistic	*df*	*p*
NS - Flexibility	.940	34	.061
DS - Flexibility	.955	34	.175
SS - Flexibility	.947	34	.098

Note. NS = No Stretching, DS = Dynamic Stretching, SS = Static Stretching
a. Lilliefors Significance Correction

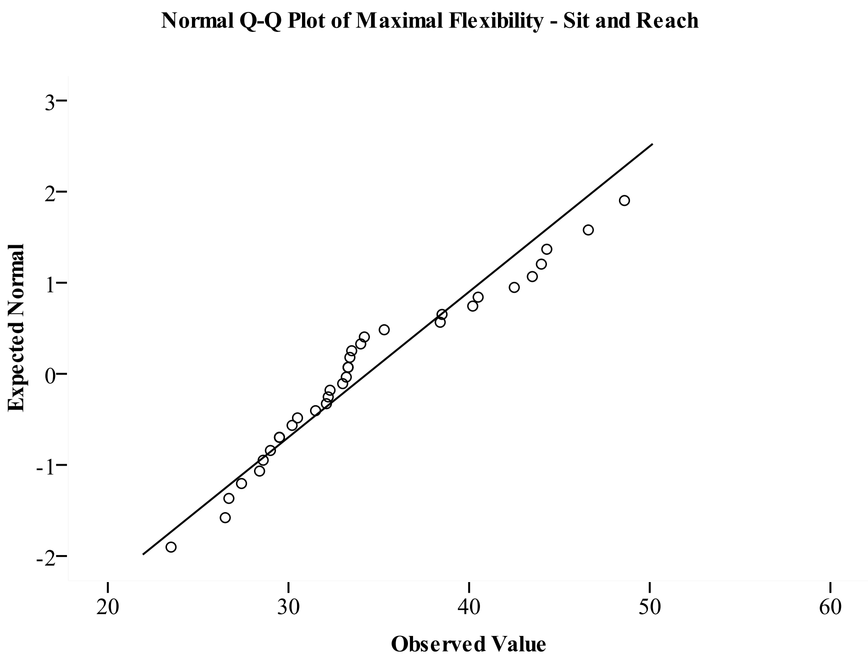

Figure 4.7 The distributions of flexibility scores

Outliers:

For outliers, the box plots were examined for the distributions for the variables. After analyzing, there was no outlier in the results of sit and reach test following three stretching interventions (Figure 4.8).

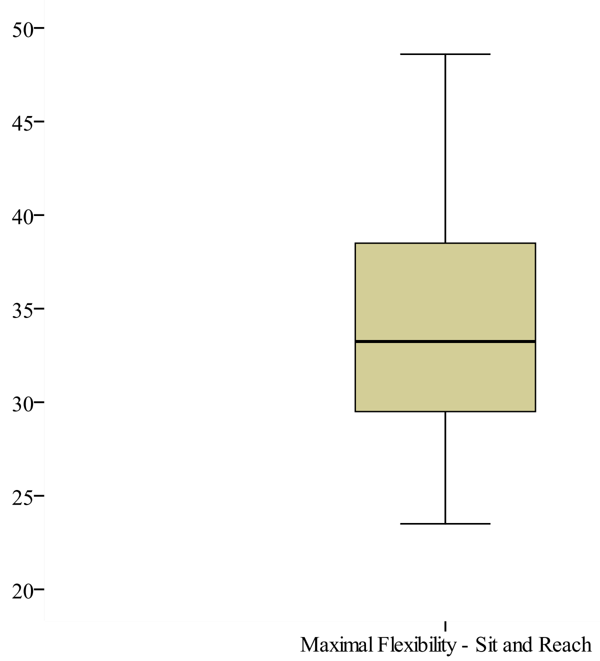

Figure 4.8 The outliers in the scores of Sit and reach test

Sphericity Assumption

Mauchly's test indicated that the assumption of sphericity had not been violated, $\chi 2$ = 3.121, $p > .005$.

4.3.2 Findings

After testing the assumptions of the repeated measures of ANOVA and observing that they were met, statistical analyze were conducted A repeated measures ANOVA showed that, for the thirty-four subjects, there was a significant difference in flexibility scores $F(1.83, 60.39) = 9.11$, $P < 0.05$). Explained total variance was 21.6 % (partial $\eta 2 = 0.216$). The repeated-measures analysis of variance revealed that the stretching conditions produced a significant increase in mean flexibility output in elite wrestlers. The flexibility scores were for NS (*M* = 34.36, *SD* = 6.26), DS (*M* = 34.84, *SD* = 6.17) and SS (*M* = 34.74, *SD* = 6.39). Thus we accepted the third hypothesis (H_O3). The means and standard deviations are presented in Table 4.8.

Table 4.8 Mean Flexibility Output After Three Stretching Condition

	N	*Min.*	*Max.*	*Mean*	*SD*
Flexibility – NS (cm)	34	23.5	48.6	34.36	6.27
Flexibility – DS (cm)	34	23.8	49.2	34.84	6.17
Flexibility – SS (cm)	34	24.1	50.4	34.74	6.39

Note. NS = No Stretching, DS = Dynamic Stretching, SS = Static Stretching

To look at where those differences occurred, Bonferroni test (Table 4.9) was run to make pairwise comparisons and it indicated that significant differences were observed between NS and DS ($p < .05$), and NS and SS ($p < .05$) but not in between DS and SS ($p > .05$) despite the increased test results of the flexibility after DS protocol but it was not enough to be statistically significant.

Table 4.9 Comparison of Stretching Protocols for Flexibility

Flexibility		*Mean Difference*	*p*
NS	DS	-.479*	.002
	SS	-.385*	.001
DS	SS	.094	1.000

Note. NS = No Stretching, DS = Dynamic Stretching; SS = Static Stretching
*. The mean difference is significant at the .05 level.
a. Adjustment for multiple comparisons: Bonferroni.

CHAPTER 5

DISCUSSION

5.1 Stretching and Power

In this study, the standing long jump test was chosen as a field test to measure the differences in power after the stretching protocols. The standing long jump, as a horizontal jumping ability test, even though related in terms of simplicity of running and equipments necessary interestingly seems to become a less preferred testing protocol. Standing long jump ability has, on the other hand, revealed significant correlation with ski jump distances although countermovement vertical jump ability revealed non-significant correlation with ski jump distances (Fleck, 1992). This implies that horizontal jump ability test might be a superior protocol than vertical jump test while measuring the progress in power and observing performance improvements for power oriented athletic events The standing long jump test has also been reported to be both valid and reliable (Pinero et al., 2010, Markovic et al., 2004). Similarly, standing long jump tests seem to become the most valid field-based muscular fitness tests as compared to isokinetic strength (Artero, 2012).

The first (H_O1) hypothesis for this study projected that there will be no differences after stretching protocols in power. The findings of this study discovered that none of the stretching types significantly affected the power scores of the elite wrestlers. The first null hypothesis is accepted. However, following the dynamic stretching (DS) protocol, power values of wrestlers have shown an increase despite it was not significant ($p < .05$). Wrestlers tended to perform better in power after DS protocol when compared to static stretching (SS). Various studies showed significant effect on jumping performance as a measure of power following DS.

Various studies presented no effect of stretching protocols in power. Reiman et al., (2008) suggested that the type of stretching has no effect in power in college students after studied the effect of SS on peak torque production of the quadriceps. They did not reach significance in differences of the subjects' result before and after 30 seconds stretching interventions. Similar to our study result, Christensen and Nordstrom, (2008) studied power and found that vertical jump performance was not affected significantly by DS protocol. Zourdos, (2012) researched the effect of DS on running energy costs and endurance performances in conditioned athletes. According to these findings, they stated that DS did not influence running endurance performances in trained athletes

Contrary to the results of our study, there are overwhelming numbers of studies revealing that DS was beneficial to power outcomes. Yamaguchi and his colleagues (2007) advised that DS types in warm-ups improved power performances. Besides, Colak (2012) stated that DS had positive effects on muscle strength and ROM, and Gourgoulis et al., (2003) explained that for a strong and physically well trained individual, a DS may gain considerable performance benefit such as increased jumping height. Besides, Yamaguchi & Ishii (2005) found significant increases in power in leg press tests after DS involving of 15 repetition of 5 lower body stretches. There is also, however, a further point to be considered. Stretching protocols including SS and DS before the power performances have been investigated in different subject populations. Younger subjects also produced similar results. Faigenbaum et al., (2005) recommended that previous to the performances of movements which needs a high power outcome, children must complete moderate to higher intensity DS. In their research, jump performances enhanced 1.8 to 2.8 cm and sprint ability developed by 0.2 to 0.3 second after dynamic warm up treatment.

DS is also advantageous for having sport specific movements. Ramachandran et al., (2014) concluded that plyometric training combined with DS for two weeks is a useful sport specific training strategy to improve vertical jump height on trained basketball players. DS is a suitable protocol for sport specific movements for the convey of energy starting from a tendon to a muscle to reach maximum forces. McMillan et al., (2006) also stated that a DS involving callisthenic movements and movement drills caused in significantly enhanced performances in medicine ball throw (body power), and 5 step jumps in athletes.

Numerous studies which compared DS with SS also presented benefits of DS in performance. Yamaguchi et al., (2005) executed a study on power with groups executed five stretch movements for a sum of four minutes. The group of DS completed five movements for single set of five repetitions. The results were consistent with the literature. The DS protocol reached significantly superior leg extension power relative to SS and a NS protocols. The positive or significant effect of DS on power is consistent with various studies, (Little and Williams, 2006, Youn and Behm, 2003, Herman and Smith, 2008, Turki et al., 2014, Curry et al, 2009, Vetter, 2007, Bafghi and Khorasani, 2013, Ce et al., 2008). In our study, none of the stretching protocols significantly affected the power scores of wrestlers. Although this may be true, mean power scores of wrestlers (M = 229,88) after DS is higher than NS (M = 229,62) and SS (M = 229,82). These findings of our study were also consistent and supportive of the related literature showing no change in power after the stretching protocols, Reiman et al., 2008, Egan et al., 2006, Cramer et al., 2007, Dalrymple et al., 2010.

SS has been criticized by scientists and professionals about its negative effect or no effect in performance of competitive athletes. Our findings disclosed that SS did not reach significant effects on power when compared with DS and NS. However, subjects performed slightly better power scores after SS compared to NS, and slightly lower scores than DS. Overall, the effect of SS on power was not significant. Accordingly, Yamaguchi et al., (2005) declared that SS for 30 second neither improve nor reduce muscular performances and that DS enhances muscular performance. Little et al., (2006) concluded that SS did not happen to become harmful to athletic performances.

Although there are still some contradictory evidences regarding benefits of stretching, SS received most of the critics due to its disadvantageous on performance outcomes. It is, for this reason, important to note the limitations of SS. It was presented that power was lowered with acute bouts of SS (McMillian et al., 2006, Cornwell et al., 2001, Young & Behm, 2003). Cornwell et al.,(2001) informed that near 4.4% reduction in jump height was resulted by a pre-event SS and these results were also reached by Young & Behm (2003). In addition, Cornwell et al., (2002) studied the acute effect of SS on active stiffness and activations in muscles and they stated that acute bouts of stretches may have detrimental effect on the performances of single-joint counter movement jumps which shows that SS routines have harmful effects in power outcomes. Elliot (2001) also presented similar significant decreases in jumping performance and explosive force after SS. Also, Siatras et al., (2008) revealed that peak torque declined in quadriceps muscles following SS for 30 and 60 second when related to a NS protocol, however, a SS of 10 and 20 second has not lowered peak torque comparing to a NS protocol. An additional study has revealed that acceleration has been affected negatively by the SS (Fletcher & Jones, 2004). The decrease in the scores due to SS has been related to a raise in muscle tendon unit lengths and a reduce stiffness in muscles (Siatras, 2008). It has noted that longer SS durations seem to create harmful effects on performances in athletes, which is a serious problem that coaches and athletes must concentrate on when they build the trainings.

In contrast to earlier findings, however, some evidence of benefits with SS was detected. Carter et al., (2008) revealed that SS led to an overall increase in torque production. They found no significant differences in the 30 seconds SS protocol and the 60 seconds SS protocol concerning improved torque production following stretching interventions. Even though, some studies reported reduction or no effect in peak torque production after stretching protocols, this study showed that stretching protocols used for either 30 second or 60 second, created a progress in the maximum torque production of muscles. These findings are not parallel with results found by Reiman et al., (2008), Siatras et al., (2008), Cramer et al., (2007) Samuel et al., (2008), Yamaguchi et al., (2006).

On the basis of the evidence currently available, it seems fair to suggest that stretching protocols may affect the performance outcomes of athletes. Even small positive increases and differences in the performance and scores in some sports, such as track and field and gymnastics, can have a huge impact that can change the total outcome of the competition. For that reason, stretching protocol in the warm-up section should be consistent with the needs of the athlete according to the requirements of each sport. The literature certainly suggests that DS protocols could develop power related performances, for instance, sprinting and jumping. Thus, according to these researchers, DS should be used as a pre-event stretching protocol before speed and power activities. These recommendations were also supported by the findings of Fletcher & Jones (2004), and Young & Behm (2003) on the in agility movements with T-Drill time who found that DS create better results in power and speed exercises.

5.2 Stretching and Agility

Agility is a combination of speed, balance, power and coordination and requiring all these futures. The T-Drill running test was given to measure agility in elite wrestlers. Our results revealed that SS has negative effect on agility and it is significant ($p < .05$) when compared with DS and NS which means that SS has actually decreased the agility scores of wrestlers. DS protocol appeared to be significantly better protocol in terms of performance results of agility when compared to SS. The wrestlers finished the test faster and showed an increase in the time they complete the test of agility compared to SS. The second null hypothesis (H_O2) for this study failed to predict the results of the study. Thus, the second null hypothesis was rejected.

When we look at our findings in terms of DS, our study results are in agreement with earlier researches that presented increase in agility performances following a DS protocol. For instance, McMillan et al., (2006) explained that a DS ended in significantly enhanced performances in a T-Drill (agility). Moreover, in a study of wrestlers, Herman and Smith (2008) employed wrestlers in the study and they found similar results with this study that DS intervention in the daily training regimen of wrestlers produced agility performance enhancements. Similarly, Ramachandran et al., (2014) reached improvements in agility with plyometrics training combined with DS on trained basketball players. Addition to the literature on the sprint and agility, Little and Williams (2006) found decreased 10 meter and 20 meter sprint time, in addition to zig-zag (agility) drill time after dynamic exercises of lower body but reported no change in counter-movement jump (CMJ) performance. Additionally, Kaetwong et al., (2012) found that DS protocols created significantly greater results in sprint time in 50-m and 100-m than did the pre-intervention.

Additionally, Patric (2010) also revealed parallel findings to our study that DS resulted in the fastest agility test time. Siatras et al., (2008) stated a decline in the time in agility test following DS, but their results were not statistically significant. The findings of Siatras et al., (2008) were exactly similar and supportive of our results of the effects of DS on agility. We also did not find statistically significance ($p > .05$) in agility after either DS or SS compared to NS but the means of DS ($M = 229.879$, $SD = 14.103$) and SS ($M = 229.815$, $SD = 14.317$) were higher than NS ($M = 229.621$, $SD = 13.836$) protocol. Although Siatras et al., (2008) did not find significance, significance was found in the study of McMillian et al., (2006) with the DS ended in significantly enhanced performance in T-Drill. This was another example study to use the T-test for agility. The results of study by Faigenbaum et al., (2006) also supported our study; they hired adolescents in the study and discovered that the agility performance went down significantly after SS as compared to DS. This result present that adolescents as well as adult athletes can experience improvements from DS. Considering these findings from the literature, our results were consistent with previous research and DS seems to have advantage over SS.

SS protocol appeared to be significantly unfavorable protocol in terms of performance results of agility when compared to DS and NS. The wrestlers finished the test slower and showed an increase in the time they complete the test of agility compared to NS. There was also a significant difference in times of agility between SS and DS in wrestlers, which means that SS protocol did not cause any significant increase in the performance values of wrestlers in agility compared to DS. In other words, the current study found SS previous to agility activity had harmful effects on agility performances. Similarly, Paradisis et al., (2014) revealed that SS drastically flawed sprint performances and explosive power in youth and in order that the types of stretches utilized in youth are recommended to be chosen carefully.

Although, Troumbley (2010) did not suggest SS prior to agility, Bafghi and Khorasani (2013) found opposite significant findings on agility time with static and no stretching methods and they suggested that soccer players most likely achieve better agility scores after DS as compare to SS. However, Little and Williams (2006) stated that the SS has not affected agility in trained soccer players. A suggestion made by Chaouachi et al., (2010) that trained individuals should engage in sufficient warm-ups and dynamic sport specific activities with no less than 5 or more duration of recovery prior to the athletic event. As a proposed solution to the negative effect of SS on performances, Amiri-Khorasani (2010) suggested that SS did not seem to be harmful for agility performances if joint with dynamic warm up for trained soccer players. On the other hand, DS throughout the warm up was the most effective stretching type to prepare for agility performances.

Previous researches have presented an actual decline in agility performance after an acute session of SS (Faigenbaum et al., 2005, McMillian et al., 2006). There might be many reasons of the decrease in performance measures, however, one of them could be the reduce in stiffness in the musculotendinous units (MTU) that result in a raise in tendon slack, requiring extra time to be acted in as soon as the muscles contract. The mentioned tendon slack leads to less efficient transfers of force from muscles to the levers (Avela, Kyrolainen, & Komi, 1999). The other reason might be the negatively affected neurological sensitivity by SS which result in diminished neural drives to the muscles that equalize to declined muscle activations in the stretch reflexes (Avela et al., 1999). The literature talks about another reason of this decrease in performance which is the amortization phase. This phase has simply the transitions between the eccentric loading and the beginning of the concentric muscle actions. To efficiently consume the reserved energy of the eccentric loading, the amortization phase should last a short time. When the amortization phase is extended too long, this reserved energy from the eccentric phase is wasted and disseminated as heat. This energy loss in the eccentric loading may result in decreased performance in the athletic events. (Potach, 2004).

Most of the tests in the above studies last no longer than 30 seconds, which is anaerobic. The tests in our study, as well, lasted 12 seconds maximum which is also anaerobic. These results back up the fact that anaerobic events with short durations positively benefit from DS. Needham et al., (2009) also looked into anaerobic performance and investigated the acute effects of various warm up routines on anaerobic performances in elite youth soccer players. They required countermovement jumps took after 10- and 20-meters sprint tests instantly and at 3 and 6 min. following warm up protocols. The results are consistent with the previous researches and they found that DS with the addition of resistance improves ability of jumping more than DS only. They additionally stated that DS creates a greater sprinting and jumping performances comparing to a warm up involving of SS. According to the researches on DS, DS is better because it can be organized according to each individual type of sport, prepares the nerves and the muscles for specific sport movements, more time efficient and saving energy for the rest of the training.

5.3 Stretching and Flexibility

The findings of this research revealed that SS has positive effect on flexibility outcome in elite wrestlers. When compared SS with DS, we found no significant deference between SS and DS ($p > ,05$) even though subjects performed slightly higher scores with DS. However, they reached significantly better flexibility scores after SS when compared to NS ($p < .05$)

which means that SS has acutely increased the agility scores of wrestlers more than NS did. Moreover, the subjects have reached better flexibility distances after DS protocol, which was also significant when compared to NS ($p < .05$). The third (H_O3) hypothesis for this study projected that stretching types does not have a significant effect on flexibility values of subjects. The results of this study presented that stretching protocols significantly affected the flexibility scores of the elite wrestlers. The third null hypothesis is rejected.

The results of our study were consistent with various studies in the literature, such as, the study by Turki et al., (2014) found that the SS and DS training protocols created similar improvement in flexibility compared to the control group. They presented that the involving DS and SS in the standard warm-up might develop flexibility. In two similar studies, Mojock et al., (2011) found that the SS evaluated by sit-and-reach improved flexibility outcomes and Siatras and his colleagues (2008) found a significant knee joint flexibility increases ($P < 0.05$). Also, Samukawa et al., (2011) found that ankle dorsiflexion ROM improved significantly following the DS ($p < 0.05$). The study on younger subjects carried out by Paradisis et al., (2014). They studied the acute effects of static (SS) and DS (DS) in flexibility in adolescent subject and they found that both SS and DS enhanced performance with SS as more beneficial (12.1%) compared to DS (6.5%). Similar to the results of our study, they suggested that dynamic warm-up protocol may be a better pre-activity warm-up choice than SS protocol.

The flexibility values of wrestlers after DS protocol showed that DS has significantly increased flexibility compared to NS values in wrestlers. This means that the wrestlers reached higher state of hamstring flexibility following DS protocol. This result is consistent with the previous research. Hamstring flexibility is vital for wrestlers. Aguilar et al., (2012) found that DS warm-up significantly improved eccentric quadriceps strength and hamstrings flexibility. In a different range of motion study, Behm et al., (2011) revealed that the length of SS led to positive effects on flexibility and the sit and reach test results with the 60 second and 90 second SS protocols respectively was greater than with the 30 second protocols. In recent range of motion study, Herda et al., (2013) found that passive ROM improved as passive stiffness and passive resistive torque declined after DS protocol.

It is a common understanding of coaches and athletes that hamstring flexibility is crucial for successful performance in many sports. There has been an interest in flexibility improvements of subjects by researchers after different type of stretching protocols. For instance, after Aguilar et al., (2012) revealed a significant increase in hamstring flexibility after DS routine, they suggested DS as a superior preactivity warm-up choice than an SS. For the most part, the advantageous of DS over SS may turn to be the effect of higher muscular temperature and voluntary contractions of fast twitch muscle fibers. The explanation in which DS improves following athletic performance might be connected to the increment in central programming of muscle contractions/coordination and declined exhaustion throughout increasing warm up activities (Shrier, 2007).

In the same manner, the range of motion studies offered positive results in terms of DS, Amiri-Khorasani (2011) found a significant difference in dynamic range of motion (DROM) after the DS and they stated that elite soccer players may execute superior DROM of the hip joint in the instep kick following DS integrated in the warm up. Besides, Weijer et al., (2003) revealed a significant increment in hamstring size and might be sustained for up to 24 hours. DS before the physical events might develop performances by extending joint ROM and core body temperature, resulted in improved blood flow to the muscle and faster nerve impulse conductions (Power, 2004). DS has been shown to be helpful in extending ankle joint flexibility (Samukawa, 2011). Hence, for lengthening the tendon tissues, which is essential for wrestlers and for many other sports fields, the benefits DS on the plantar flexors were believed to be valuable.

The results of the related literature were supportive of DS as effective in increasing joint range of motion as SS (Faigenbaum et al., 2005, Herman & Smith, 2008). Therefore, we can conclude that dynamic and SS protocols might elicit a statistically significant increase in flexibility output when comparing to the no stretching protocol according to the literature. In our study, the SS protocol and DS protocols produced very similar results to each other. The athletes did yield better distance scores after DS and SS in flexibility comparing to the NS but the difference between these two results of stretching protocols were not enough to be statistically significant.

It was initially hypothesized (H_O3) that mean flexibility output would not be significantly higher following a SS protocol than after a DS and NS protocol. The flexibility values of wrestlers after SS protocol showed that SS has significantly increased flexibility compared to NS values in wrestlers ($p < .05$). This means that the wrestlers reached higher state of hamstring flexibility following SS protocol. This result is consistent with the previous research. When there is a proper application, the SS may cause the relaxation and concurrent elongation of the stretch muscle, and the risk of injury caused by the stretch is decreased (Baechle & Earle, 2000). It was showed that SS increase range of motion (ROM) and could also reduce musculotendinous stiffness, even during short-durations (5–30 s) stretches (Bacurau, 2009). Barroso et al., (2012) reveal that SS routines significantly enhanced the range of motion (ROM) in the sit and reach test when comparing to the NS. Moreover, Woolstenhulme et al., (2006) found increase in flexibility for the SS group compared to the control group. Previous studies have showed that SS can increase the range of motion at a joint. Additionally, Kieran, Elaine and David (2009) found significantly increased hamstring flexibility following SS protocol. SS improved hamstring flexibility, while DS did not, consistent with the findings.

On the other hand, despite the benefits of the SS, Duncan & Woodfield, (2006) did not find a significant difference in low back and hamstring flexibility following three separate acute conditions (NS, DS, and SS). Similarly, Aguilar et al., (2012) found no significant effect on flexibility measures ($p > 0.05$) following static warm-up protocol but the dynamic warm-up protocol significantly improved hamstrings flexibility. These studies suggest that acute bouts of SS have little or no influence on flexibility results.

Important to note that a warm-up protocol included SS may cause the athletes to stop and wait steady following the warm-ups that might end in lowered body temperature and after that the athlete might start performing heavy workouts. In an exercise or a competition, the negative effects of SS might be seen as not reacting quickly enough, and finishing or reaching the point in a game in the required time which could make the difference. Elite and competitive athletes should react with a greatest capacity since even a small variation in performance can decide in winning and losing. For that reason, coaches, or exercise professionals who prepare or direct the warm up activity should be conscious about the potential harmful effect of SS before agility performances or related sports.

CHAPTER 6

CONCLUSIONS & RECOMMENDATIONS

6.1 Conclusions

In our study, the question was if there were any significant effect of static stretching (SS) and dynamic stretching (DS) on power, agility and flexibility in competitive wrestlers.

This results of study revealed that the DS protocol had a significant effect on the time on the T-test for agility in wrestlers. The wrestlers tended to perform significantly better in agility following DS protocol. This current research seems to validate the view that DS has more advantages in performance related events over SS or no-stretching (NS). For that reason, professionals, coaches and athletes should take into consideration that DS would be better choice as a warm-up before agility related performances. The findings also presented that the DS protocol had a significant effect on the distance on sit and reach test for flexibility in elite wrestlers. This basically means that wrestlers improved their flexibility following DS protocol when compared to SS and no-stretching protocols. On the basis of the evidence currently available, it seems fair to suggest that DS is better selection as a warm-up before flexibility related performances for wrestlers.

Surprisingly, the results of DS protocol did not show a significant effect on the distance on the Standing long jump for power in wrestlers. However, it was observed that wrestlers tended to perform slightly better following DS when compared to SS and no-stretching. Although it was not significant, DS protocol might be still recommended for power related performances since the scores were slightly higher after all. Besides, SS protocol had a significant detrimental effect on the time on the T-test for agility in wrestlers. It actually increased the time in agility test when compared to no-stretching protocol. This means that ability of agility is affected negatively by the dynamics of SS and coaches and it is recommended that athletes may not consider SS before agility related activities and performances for wrestlers.

Another point of the findings of the study also presented that the SS protocol had a significant effect on flexibility in elite wrestlers. That mainly implies that wrestlers improved their flexibility following SS protocol when compared to no-stretching protocol. On the basis of these results at present, it appears reasonable to suggest that SS is better selection as a warm-up before flexibility related performances for wrestlers than no-stretching protocol. Lastly, the results of SS protocol did not demonstrate a significant effect on the distance on the Standing long jump for power in wrestlers. However, it was recorded that wrestlers leaned to complete faintly better following SS when compared to no-stretching. Although the effect was not large, SS protocol might be still recommended for power related performances since the scores were slightly higher after all.

The athletes participating in workouts and competitions have always been advised to warm up prior to engaging in moderate to vigorous activity. A classic warm-up normally starts with a 3 to 10 minutes of light activity followed by some stretching exercises. Here it is recommended to incorporate DS requiring large muscle groups such as high knees, lateral shuffles, crossovers and heel to toe walks to allow the participant to 'break a sweat', which is a product of raising core temperature and metabolic rate. Once their core temperature has risen, the athletes should begin their routine training. On the other hand, SS can be used during a cool-down phase of the training or workouts to support the range of motion and keep flexibility.

6.2 Recommendations for Future Research

It has been pointed out that the participants in this study are limited to the wrestling clubs in Ankara. In the future, a larger group of participants from different cities could be added to the future study. Future studies must be intended toward investigating the chronic effects of different stretching protocols on various performance outcomes. The study with a longer intervention may disclose greater developments. In the future study, there can be more researchers with extended period of time to do all the measurements. Moreover, the future research should also study the different intensity, duration and frequency of each stretching protocol on different performance outcomes. For example, it would be interesting to employ and compare DS and SS before a mile run. The results might be beneficial for endurance athletes, as well.

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Appendix A: Informed Consent Form

GÖNÜLLÜ KATILIM FORMU

Bu çalışma, Doktora Öğrencisi Murat Çelebi tarafından Ankara'da Spor Kulüplerinde spor yapan elit güreşçiler üzerinde yapılacak bir çalışmadır.

Çalışmanın amacı, ısınma egzersizleri içerisinde değerlendirilen statik ve dinamik esnetme egzersizlerinin güreşçilerde esneklik, güç ve çeviklik değerlerine etkisi hakkında bilgi toplamaktır.

Çalışmaya katılım tamimiyle gönüllülük temelinde olmalıdır. Çalışmamızda sizden kimlik belirleyici hiçbir bilgi istenmemektedir. Test sonuçlarınız tamimiyle gizli tutulacak ve sadece araştırmacılar tarafından değerlendirilecektir; elde edilecek bilgiler bilimsel yayımlarda kullanılacaktır.

Çalışma genel olarak kişisel rahatsızlık verecek soruları içermemektedir. Ancak, çalışmalar esnasında egzersizlerden ve testlerden ya da herhangi başka bir nedenden ötürü kendinizi rahatsız hissederseniz egzersizler ve testler esnasında yarıda bırakıp çıkmakta serbestsiniz. Böyle bir durumda çalışmayı uygulayan kişiye, bırakmak istediğinizi söylemeniz yeterli olacaktır. Çalışmamızın başında veya sonunda, bu çalışmayla ilgili sorularınız olursa, sorularınız cevaplanacaktır. Bu çalışmaya katıldığınız için şimdiden teşekkür ederiz.

Çalışma hakkında daha fazla bilgi almak için Beden Eğitimi Bölümü öğretim üyelerinden Doç. Dr. Sadettin Kirazcı (Oda:Beden Eğitimi ve Spor Bölümü; Tel: 210-4018; E-posta: skirazci@metu.edu.tr) ya da Doktora Öğrencisi Murat Çelebi (Tel: 542 454 9474; E-posta: celebi_murat@hotmail.com) ile iletişim kurabilirsiniz.

Bu çalışmaya tamamen gönüllü olarak katılıyorum ve istediğim zaman yarıda kesip çıkabileceğimi biliyorum. Verdiğim bilgilerin bilimsel amaçlı yayımlarda kullanılmasını kabul ediyorum. (Formu doldurup imzaladıktan sonra uygulayıcıya geri veriniz).

Adı Soyadı: ____________________ Tarih: __ / __ / ____ İmza:____________________

Appendix B: Approval of Research Procedures

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
MIDDLE EAST TECHNICAL UNIVERSITY

DUMLUPINAR BULVARI 06800
ÇANKAYA ANKARA/TURKEY
T: +90 312 210 [illegible]
F: +90 312 210 79 59
ueam@metu.edu.tr
www.ueam.metu.edu.tr

Sayı: 28620816/345-751

Gönderilen : Doç. Dr. Sadettin Kirazcı
Beden Eğitimi ve Spor Bölümü

Gönderen : Prof. Dr. Canan Özgen
IAK Başkanı

İlgi : Etik Onayı

Danışmanlığını yapmış olduğunuz Beden Eğitimi ve Spor Bölümü öğrencisi Murat Çelebi'nin "Müsabık Güreşcilerin Isınma Egsersizlerinde Statik ve Aktif Esnetmenin Etkilerinin Çabukluk, Esneklik Güç ve Reaksiyon Üzerinde ki Etkilerinin Araştırılması" isimli araştırması "İnsan Araştırmaları Komitesi" tarafından uygun görülerek gerekli onay verilmiştir.

Bilgilerinize saygılarımla sunarım.

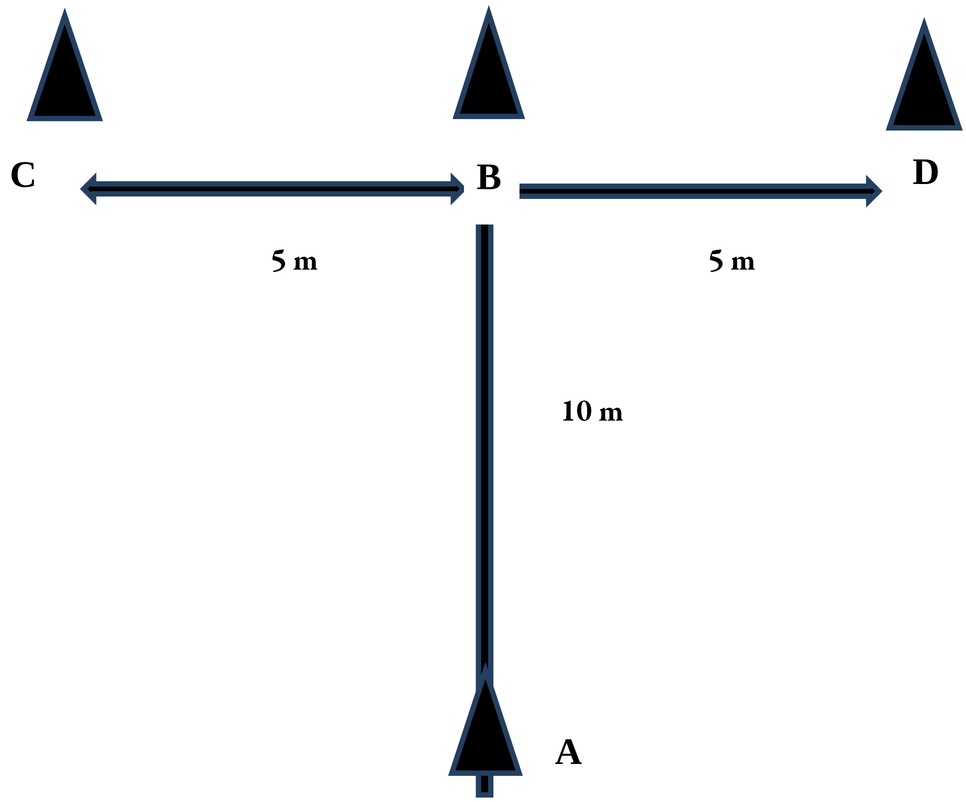
Etik Komite Onayı

Uygundur

Prof.Dr. Canan Özgen
Uygulamalı Etik Araştırma Merkezi
(UEAM) Başkanı
ODTÜ 06531 ANKARA

Appendix C

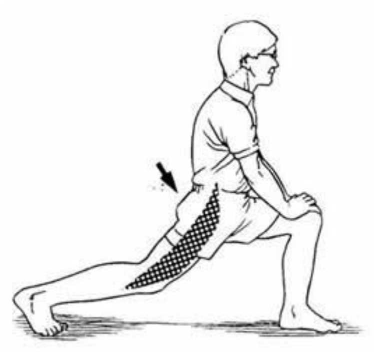
T-Drill for Agility



Appendix D

Static Stretching Protocol

Stretches	Sets	Repetitions
Gluteal Stretch • Sitting on the floor with one leg out straight, • The opposite knee is bent and the foot is placed on the other side of the straight leg. • The hands are then used to gently push the bent knee up towards the opposite shoulder. • *Muscles: Gluts*  *Static Stretch 1*	2	15 sec bilaterally
Hip Flexor Stretch • The feet are placed stride width apart, with the front knee bent. • Place hands on left leg for stability. • Keep back straight and abdominal muscles tight. • Lean forward, shifting more body weight onto front leg. • *Muscles: Hip Flexors*	2	15 sec bilaterally

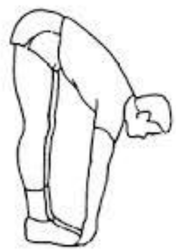


Static Stretch 2

Hamstring Stretch

- Stand and bend over with knees straight.
- Reach toward toes or floor and bring torso toward legs.
- Hold stretch.
- Keep knees straight by tensing Quadriceps.
- *Muscles: Hamstrings*

2 — 15 sec bilaterally



Static Stretch 3

Quadriceps Stretch

- Keep upper body up straight
- Pull the heel towards the bottom until feeling a strong stretch in the front of the thigh.
- *Muscles: Quadriceps*

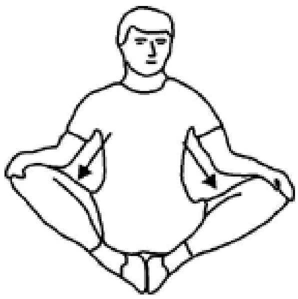
2 — 15 sec bilaterally

Static Stretch 4

Abductor Stretch

- In the seated position bend both legs and put the feet together.
- Allow the knees to lower to the ground to increase the stretch.
- Avoid bouncing and excessive upward pressure on the feet.
- *Muscles: Abductors*

2 — 15 sec bilaterally

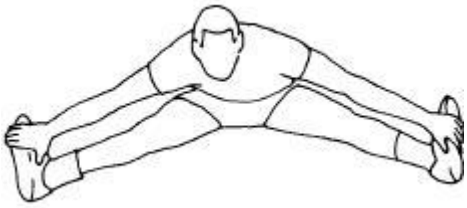


Static Stretch 5

Adductor Stretch

- Sit with legs straight out in front of you with the back straight.
- Slowly work the legs apart as far as they will go.
- Bend forward at the hips until feeling more resistance.
- Keep the knees straight and chest up
- *Muscles: Adductors*

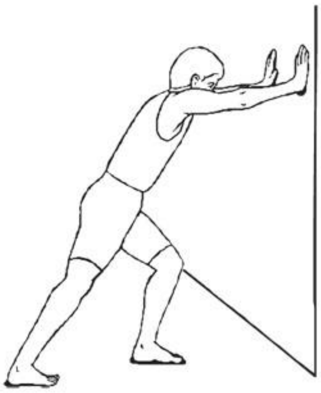
2 — 15 sec bilaterally



Static Stretch 6

Gastroc/soleus Stretch

• Stand holding onto a wall • Toes point straight forwards • Place the leg to be stretched behind • Lean forwards bending the knee until feeling a stretch in the calf. Make sure to keep the heel on the floor. • *Muscles: Gastroc/Soleus*	2	15 sec bilaterally



Static Stretch 7

Static Stretch 1, retrieved November 01, 2014, from *http://firsthealthassociates.com/health-topics/lower-back-pain-series/exercising-for-lower-back-pain---step-one-restoring-flexibility-by-emery-paredes--pt.html*

Static Stretch 2 retrieved November 01, 2014, from *http://firsthealthassociates.com/health-topics/lower-back-pain-series/exercising-for-lower-back-pain---step-one-restoring-flexibility-by-emery-paredes--pt.html*

Static Stretch 3, retrieved November 01, 2014, from *http://rugbycentric.com/stretching-flexibility/hamstring-stretches/attachment/standing-hamstring-stretch/*

Static Stretch 4, retrieved November 01, 2014, from *http://workoutlabs.com/custom-workoutbuilder/?tl1=Your%20Workout%20Title&a1=2981&b1=&c1=&d1=M&tms=1417426148*

Static Stretch 5, retrieved November 01, 2014, from *http://www.getfit.com.au/stretch/*

Static Stretch 6, retrieved November 01, 2014, from http://rugbycentric.com/stretching-flexibility/groin-stretches/

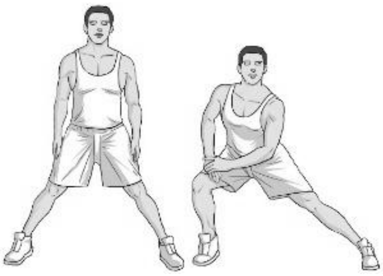
Static Stretch 7, retrieved November 01, 2014, from *http://www.walkaboutmag.com/images/32TA%20GastrocAchilles.jpg*

Appendix E

Dynamic Stretching Protocol

Stretches	Sets	Repetitions
High Knees • Stand on a smooth surface • Start jogging and lifting the knees high enough in comfort level. • Move knees up to hip level • *Muscles: Gluts/Hamstrings*  *Dynamic Stretch 1*	2	15 sec Bilaterally
Lateral Lunges • Stand with the feet near together and upper body straight, looking forward. • Take a big step to the side and keep head up and torso upright. • Lower on leading leg and keep knee in line with foot.	2	15 sec Bilaterally

- Feet should be pointing forward throughout.
- Move back to the starting position and repeat it again.
- *Muscles: Inner Thighs*



Dynamic Stretch 2

Skips

• Stand with the feet near together and upper body straight, look forward. • Step and then hop, landing on the same leg, followed by the same action with the opposite leg. • Use strong arm action to support the movement. Hands should move from waist to chin level with an approximately 90˚bend in the elbows throughout. • When the right leg is forward, the left arm swings forward and the right arm is to the rear. When the left leg is forward, the right arm swings forward and the left arm is to the rear. • *Muscles: Hip flexors, gluteals, quadriceps*	2	15 sec Bilaterally

Dynamic Stretch 3

Lateral Shuffles

- Stand vertical to the direction of movement, in a slight crouch with the back straight.
- Step to the side by rising slightly and bringing the trailing leg to the lead leg. Quickly hop to the side and land back in the crouch with the knees shoulder-width apart. Repeat the moves.
- *Muscles*: *Abductors/Adductors*

2

15 sec Bilaterally

Dynamic Stretch 4

Heel to Toe Walk

- Position the heel of one foot just in front of the toes of the other foot. The heel and toes should touch or almost touch.
- Keep you steady as walking
- Take a step. Put the heel just in front of the toe of the other foot.
- *Muscles: Gastroc/soleus*

2

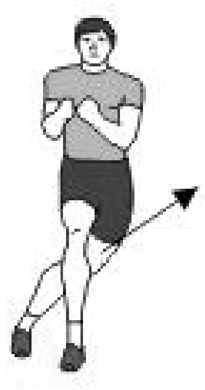
15 sec Bilaterally

Dynamic Stretch 5

Crossovers (carioca)

- Stand perpendicular to the direction of movement.
- Cross the trailing leg to the front of the lead leg and step in the direction of travel to return to the starting position. Then cross the trailing leg to the rear of the lead leg and step in the direction of travel to return to the starting position. Repeat it.
- Let the arms swing naturally side to side to support balance. Allow the hips to turn naturally
- *Muscles: Adductors and Abductors*

2 — 15 sec Bilaterally



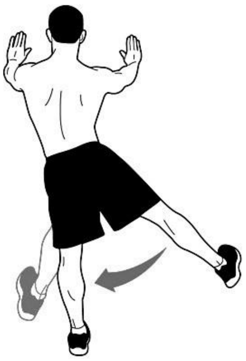
Dynamic Stretch 6

Crossovers leg Swings

2 — 15 sec Bilaterally

- Stand side on to a wall with the weight on the left leg and the right hand on the wall for balance. Swing the right leg forwards and backwards.

- *Muscles: Adductors and Abductors*



Dynamic Stretch 1, retrieved November 01, 2014, from *http://www.fitbie.com/sites/default/files/high-knee-run-b-ex.jpg*

Dynamic Stretch 2, retrieved November 01, 2014, from *http://www.menshealth.com.sg/fitness/15-min-workout-muscles-every-runner-must-train*

Dynamic Stretch 3, retrieved November 01, 2014, from *http://coachjohannes.blogspot.com.tr/2012/10/coach-jos-20-minute-legs-plyo-challenge.html*

Dynamic Stretch 4, retrieved November 01, 2014, *from* *http://www.protraineronline.com/wp-content/uploads/2013/04/0413_LateralShuff.jpg*

Dynamic Stretch 5, retrieved November 01, 2014, from *http://www.harvardprostateknowledge.org/sites/default/files/images/POPD1008d-21.jpg*

Dynamic Stretch 6, retrieved November 01, 2014, from *http://www.runnersworld.com/sites/default/files/rt/images/201004/Stretches_Carioca.jpg*

Dynamic Stretch 7, retrieved November 01, 2014, from *http://www.fitbie.com/sites/default/files/leg-pendulum-stretch-ex.jpg*

Appendix F

Curriculum Vitae

PERSONAL DETAILS

Name: Murat Çelebi
Date of Birth: 09/10/1974
Place of Birth: Ankara
Current Occupation: Research Assistant

CONTACT DETAILS

Telephone: +90 542 454 94 74
Post: Kuscagiz Mh. Kartaltepe Cd. 36/9 Keçiören Ankara
Electronic Mail: celebi_murat@hotmail.com

EDUCATIONAL DETAILS

Secondary Education: Ulus Teknik ve Endüstri Meslek Lisesi, 1993
Tertiary Education: B.S. 1993-1999 METU - Physical Education & Sports Department
M.Sc. 2000-2002 Northern Michigan University, NMU – USA Health and Physical Education & Sports Department

EMPLOYEMENT AND EXPERIENCE

2013 – 2014 - Sura Ltd Company, General Manager
2010 – 2011 - Advisor to a Member of Parliament
2008 – 2010 - Youth and Sport Ministry, Wrestling Coach
2004 – 2007 - Zafer Computer, General Manager
2000 – 2002 – Olympic Education Center, Assistant Coach
2000 – 2002 – Northern Michigan University, Teaching Assistant
1999 – 2000 – University of Minnesota-Morris, Assistant Coach

RELEVANT SKILLS

- Life Saving Certificate Turkish Under Water Sports, Life-Saving, Water Ski and Fin Swimming Federation - Bronze Sportsman

RESEARCH INTERESTS

- Physiology of exercise

Appendix G

Turkish Summary

Güreş sporu bütün sporlarının en eskisi olarak kabul edilmektedir. Antik Olimpiyatlarda yer almış bir kaç spor dalından bir tanesidir. Güreş bünyesinde müsabaka kazandıran veya bir tekniğin başarılı bir şekilde uygulanmasını sağlayan birçok performans dinamiklerini taşıyan bir spordur. Güç, çeviklik ve esneklik Olimpik güreş sporunun bu önemli ana özeliklerinden bazılarıdır çünkü bu özellikler güreş antrenman ve müsabakalarında başarılı olmak için önemlidir.

Esnekliği sağlayıcı germe aktiviteleri her bir antrenman da ve her bir spor dalında farklılıklar gösterebiliyor. Antrenörler ve sporcular antrenmanlardan önce ısınma kısmında atletik performans için hangi germe protokollerinin en iyisi olduğunu bilmek ister. Literatürde aynı amaç için farklı germe protokollerinin tavsiye edildiğini görürüz. Bazı araştırmacılar germenin atletik performansa olumsuz bir etkisi olmadığını açıklarken (Dalrymple, Davis, Dwyer & Moir, 2010; Beedle ve diğ., 2008) bazı araştırmacılara göre germe egzersizlerinin performansı olumlu etkilemekte olduğunu gösterirler (Curry, Chengkalath, Crouch, Romance & Manns, 2009; Vetter, 2007; Bacurau ve diğ., 2009). Farklı araştırmacılar da statik germe , dinamik germe ve kontrol protokollerinden sonra performansta anlamlı bir fark bulamamışlardır (Dalrymple ve diğ., 2010).

Uzun yıllar boyunca statik germe hareketleri ısınma bölümünün önemli bir parçası olarak kabul edildi. Statik germe bir vücut parçasının hareket menzili limitlerine doğru hareket ettirilerek ve 15-60 saniye sabit tutularak uygulanmaktadır (Young & Behm 2002). Statik germe bir eklemin hareket menzilini geliştirmek için faydalı bir pratik olarak tercih edilmektedir (Power et al. 2004). Bununla beraber statik germe hareket menzili içerisinde kasta ki duyusal alıcıların nöromüsküler tepkilerini eğitmek için 10 - 30 saniye kadar tutulabilecek yavaş ve emin bir harekete sahiptir (Kaminsky, ve diğ., 2006). Statik germe bir eklem veya bir eklem gurubunun hareket menzilini geliştirerek sakatlanmaktan koruduğu için tavsiye edilir (Hendrick, 2004).

Literatür yoğun fiziksel aktiviteden önce iyi yapılandırılmış ısınma protokolü ile sakatlık tehdidinin azaltılabileceğini gösterir (Alter, 2004). Sakatlığın azaltılması ve önlenmesi için, bazı çalışmalar fiziksel aktivitenin başlangıcında statik germe protokollerini önerir (Safran ve diğ., 1989). Ayrıca, kas ağrılarında ki azalma ve performansın artması statik germenin faydaları olarak kaydedilmiştir (High ve diğ., 1989; Young & Behm, 2002). Bu sebeplerden dolayı germe ve ısınma rutinleri müsabakaya yönelik atletik performans çıktılarını değiştirebilme ve gelecekteki sakatlanmaları önleyebilme yeteneğine sahip olabilir.

Statik germe protokollerinin sonuçları düşünüldüğünde, ortalama koşu hızında azalma tespit edildi (Siatras, 2003) ya da hiç bir değişiklik olmadığı (Little, 2006) belirtildi. Dikkatli uygulandığı zaman germe teknikleri sayesinde sakatlanma riski azalır (Baechle & Earle, 2000). Literatüre göre statik germe hareket menzilini geliştirir ve kastaki sertliği azaltır, hatta bu daha kısa yapılan germe egzersizleri içinde aynıdır (5–30 s) (Bacurau, 2009). Buna ek olarak, American College of Sports Medicine (ACSM) kılavuzunda (ACSM's Guidelines for Exercise Testing and Prescription, 2005) germe süresinin 15 ila 30 s uzunluğunda olmasını tavsiye etmektedir.

Literatürde birçok çalışma statik germenin performans açısından olumsuz etkileri olduğuna dair bulgular sunmaktadır, örneğin, Kistler ve arkadaşları (2010) statik germe egzersizlerini 100 m.'ye kadar olan kısa mesafe koşucuları için fiziksel aktivite başlangıcında dâhil etmenin zararlı olduğunu göstermiştir. İlave olarak, statik germe sporcuların maksimal kuvvetlerinde zararlı etki oluşturduğu tespit edilmiştir (Costa, 2009). Dayanıklılık sporcuları açısından bakıldığında, elit sporcuların orta derece yoğunluğunda bisiklet antrenmanlarından önce statik germe tekniklerini akut bisiklet ekonomisini azalttığı için çıkartmaları tavsiye edilmektedir (Wolfe, 2011). Koşu açısından bakıldığında, statik germe 3-km koşu zaman-denemesi esnasında yavaş başlangıca sebep olan nöromüsküler fonksiyona zarar verdiği bulunmuştur (Damasceno, 2014).

Performans açısından Germe süresi de önemlidir. Siatras ve arkadaşları (2008) bazı statik germe sürelerinin maksimal tork üretimi üzerindeki akut etkilerini araştırdılar. Sonuç olarak, 30 saniye üzerindeki statik germe hareketlerinin yüksek kuvvet gerektiren aktivitelerden önce uygulanmaması gerektiğini tavsiye ettiler. Robbins & Scheuermann (2008) faklı sure ve yoğunluklar da ki akut statik germe egzersizlerinin sıçrama performansı üzerinde ki bağlantısını araştırdılar. Sıçrama ve koşu gibi güç isteyen egzersizlerden 90 saniye önce veya 6 setin üzerinde germe egzersizlerini tavsiye etmediler. Costa ve arkadaşları (2009) farklı uzunluktaki statik germe egzersizlerinin dinamik denge üzerinde ki etkilerini araştırdı ve 45 saniye boyunca tutulan statik germe egzersizlerinden sonra dengenin olumsuz etkilenmediğini açıkladı. Fakat 15 saniye boyunca tutulan statik germe hareketlerini dengeyi geliştirebilir. Bu çalışma sonuçlarına göre eğer antrenmanın amacı denge ise, kısa sureli statik germe hareketleri tavsiye edilmektedir (Knudson, 2001). Bu çalışma bizim protokollerde kullandığımız germe süresini (15 saniye) kullanmış ve denge açısından olumlu sonuçlar bulmuştur.

Bazı çalışmalar Statik germenin olumsuz etkilerinin sebeplerini araştırmış ve statik germenin olumsuz etkilerini sinirsel ve mekanik faktörlere bağlamışlardır (Avela, Finni, Liikavainio, Niemela, & Komi, 2004). Cramer ve arkadaşları (2005) maksimal istemli hareket esnasında motor ünite aktivasyonunu azalttığını buldular. Başka bir çalışmanın verilerine göre, statik germe kas tendon ünitelerinin uzunluğu ve sertliğini değiştirmektedir (Kato, Kanehisa, Fukunaga, & Kawakami, 2010). Bu kas tendon ünitenin uzunluğu, sertliği ve kas aktivizasyonunda ki değişiklik reaksiyon zamanını ve hareket zamanlarını etkileyebilir (Behm, Bambury, Cahill & Power, 2004). Buna ek olarak, kuvvet değerlerinde (Fowles, Sale, & MacDougall, 2000), sıçrama sonuçlarında (Cornwell, Nelson, Heise & Sidaway, 2001) ve koşu performansında (Fletcher & Annes, 2007) anlamlı bir azalma tespit edildi. Yukarda ki bilimsel çalışmaların gösterdiği statik germe kaynaklı potansiyel performans bozulmalarından dolayı, dinamik germe protokollerine doğru artan bir eğilim gözlenmektedir.

Statik germe protokollerinin olumsuz etkilerini gösteren çalışmalara rağmen, bazı araştırmacılar statik germenin performans üzerinde ki azalan zararlı etkilerini göstermekte veya olumsuz etkilerinin olmadığını gösteren sonuçlar sunmaktadırlar. Mizuno ve arkadaşları (2014) statik germe egzersizlerini takiben kısa sure içerisinde olumsuz etkilerinin ortadan kaybolduğunu açıkladılar. Egan ve arkadaşları (2006) statik germe egzersizlerinden sonra ortalama güç değerlerinde ve tork da hiç bir olumsuz etki bulmadıklarını bildirmişlerdir. Statik germenin elit sporcularda maksimal kas kasılmaları esnasında güç üzerinde herhangi bir olumsuz etki oluşturmadığını ifade ettiler. Diğer bir çalışmada da statik germe maksimal tork ve güç üretimini olumsuz etkilemediği bulundu (Cramer, 2007)

Yöntem

Katılımcılar

Bu çalışmaya 34 elit müsabık erkek güreşçi katılarak dinamik germe ve statik germe protokollerini uyguladılar (yaş = 20.1 ± 2.0, boy = 171.0 ± 3.2 cm; kilo = 75 ± 5.2 kg). Katılımcılar Ankara'da kulüplerde güreş yapan, Türkiye'de ulusal seviyede güreş yapmakta olan ve son altı aydır herhangi bir sakatlık geçirmemiş güreşçilerden oluşmaktadır. Katılımcılar yaptıkları spor dolayısıyla testlerde kullanılan germe protokollerine daha önceden aşinadırlar. Katılımcıların isimleri kayıt altına alınmadı.

Araştırma Dizaynı

Dinamik germe, statik germe ve germesiz protokollerinin güç, çeviklik ve esneklik üzerinde ki etkilerini belirlemek için guruplar-içi değişken deneysel dizaynı kullanıldı. Katılımcılar her gün bir tanesi yapılan germe protokollerinden sonra Durarak uzun atlama, T-Drill ve

Otur ve uzan testi ölçümlerini gerçekleştirilerek katılımcıların güç, çeviklik ve esneklik değerleri belirlendi ve analizi yapıldı. Bağımsız değişken 3 farklı germe boyutu (dinamik germe, statik germe ve germesiz) olan 3 germe şeklidir. Bağımlı değişken güç, çeviklik ve esnekliktir.

Araştırma Dizaynı

PROTOKOLLER	**Germesiz**			**Dinamik Germe**			**Statik Germe**		
Test Günleri	1. Gün	2. Gün	3. Gün	1. Gün	2. Gün	3. Gün	1. Gün	2. Gün	3. Gün
Koşu (5 dk)		+	+	+	+	+	+	+	+
Germe (10 dk)				+	+	+	+	+	+
Güç	+			+			+		
Çeviklik		+			+			+	
Esneklik			+			+			+

Veri Toplama Prosedürü

Bu çalışma Orta Doğu Teknik Üniversitesi İnsan araştırmaları Etik Komitesi tarafından onaylandı (EK B). Ölçümlerden önce, katılımcılar antrenman merkezinde toplandılar ve çalışmanın detayları hakkında bilgilendirildiler. Bu toplantıda katılımcılar Bilgilendirilmiş rıza formunu (Ek A) okuyup imzaladılar. Prosedürler katılımcılara açıklandı, çalışmada bulunan riskler anlatıldı. Her bir katılımcı 9 kez test edildi. Her bir test arasında en az 24 saat zaman vardır. Katılımcılar hangi germe protokolünü yapacaklarını bilmiyorlardı. Bu bakımdan dizayn tek-kör kontollü çalışmadır.

Her bir germe protokolü 5 dk süren hafif şiddetli koşu içeren ısınma (Curry ve diğ., 2009; Tsolakis, 2012, & Zimmer ve diğ., 2007) ile başladı. Maksimal ölçümlerde, ısınmayı takiben 1 dk'lık dinlenmeden sonra katılıcılar testlerden birisini (Durarak uzun atlama, T-Drill, Otur ve uzan) 3 farklı günde uyguladılar. Dinamik ve statik germe protokolleri yaklaşık olarak 10 dakika sürdü. Araştırmacı bir kronometre ve germe hareketlerinin listesini elinde hazır bulundurdu, bu sayede katılımcılara ne zaman germe hareketlerini değiştireceklerini ve hangi germe hareketini yapacaklarını bildirdi. Her bir test arasında 1-dk dinlenme vardır (Bradley, P.S., Olsen, P.D., and Portas, M.D., 2007 & McMillan, 2006).

Güç Testi – Durarak Uzun Atlama

Bu test bacakların patlayıcı gücünü ölçen bir testtir. Araştırmacı atlanılan mesafeyi bir metre vasıtasıyla ölçtü ve atlama ve düşüş için kaymayan zemin kullanıldı. Düşüş çizgisi açıkça görünecek şekilde işaretlendi ve bu sayede katılımcılar görebildiler. Katılımcılar ayakları hafif açık olarak başlangıç çizgisinin arkasında durarak atlamaları gerçekleştirdiler. Katılımcılar atlayabilecekleri en uzun mesafeye ve arkaya düşmeden iki ayakları yere aynı anda inecek şekilde atlamaya çalıştılar.

Durarak uzun atlama testi germe protokollerinden sonra güç değerlerinde ki farklılıkları ölçmek için saha testi olarak seçildi. Durarak uzun atlama testi kuvvet, patlayıcı kuvvet ve güç testi olarak dünya çapında geniş çapta kullanılan bir testtir (Pate, Oria, & Pillsbury, 2012). Yatay zıplama testi güç odaklı performanslarda güç ve performansın gelişimini takip etmekte dikey zıplama testinden daha iyi bir protokol olabilir (Castro-Piñero ve diğ., 2010). Paralel olarak, durarak uzun atlama testi isokinetik kuvvet ile karşılaştırıldığında en geçerli saha-temelli fitnes testi olarak görünmektedir (Artero, 2012).

Aşağıdaki formül zirve güç değerlerini bulmak için kullanılmıştır.

Zirve Güç (W) = 60.7 × (Zıplama Mesafesi [cm]) + 45.3 × (Vücut Ağırlığı [kg]) − 2055.
(Sayers ve diğ., 1999).

Sonuçlar

Germe protokolleri arasındaki ilişkiyi ve etkilerinin güç, çeviklik ve esneklik değerleri üzerindeki etkilerini hakkında ki esas hipotezleri test etmek için üç farklı tekrarlı Anova kullanıldı.

Güç

Güç germe çeşitlerinin katılımcıların güç değerleri üzerinde anlamlı bir etkisi olmadığını ifade eden birinci hipotezi test etmek için durarak uzun atlama testi sonrasında ölçüldü. Analizlerden önce, tekrarlı Anovanın varsayımları kontrol edildi. Buna göre, bağımsız değişken normal dağılım gösterdi ve Shapiro-Wilk Testin değeri 0.05 ($p <.05$)'den daha büyük olarak bulundu. Uç değerler açısından bakıldığında, boxplot dinamik germede 13,316.7 W değerinde 1 uç değer (5) gösterdi. Uç değer çıkartılarak analiz tekrar yapıldığında, dağılım normal göründü ve uç değer tespit edilmedi. Son olarak Mauchly'nin küresellik testi küresellik varsayımının sağlandığını göstermiştir χ^2 (2) = .790, p = .674.

Sonuçlar germe protokolleri sonrasında katılımların güç değerlerinde anlamlı bir artış göstermedi. Germesiz protokol (*M* = 15.359.4, *SD* = 934.2), dinamik germe protokolü (*M* = 15.371.4, *SD* = 945.09) ve statik germe protokolü (*M* = 15.370.3, *SD* = 961.2), F (2, 66) = .376, $p > 0.05$). Anlamlı bir artış olmamasına rağmen, dinamik germe protokolünden sonra katılımcıların güç değerlerinde azda olsa bir artış gözlenmiştir.

Çeviklik

Çeviklik, germe çeşitlerinin katılımcıların çeviklik değerleri üzerinde anlamlı bir etkisi olmadığını ifade eden ikinci hipotezi test etmek için T-Drill testi sonrasında ölçüldü. Analizlerden önce, tekrarlı Anovanın varsayımları kontrol edildi. Buna göre, bağımsız değişken normal dağılım gösterdi ve Shapiro-Wilk Testin değeri 0.05 ($p < .05$)'den daha büyük olarak bulundu. Uç değerler açısından bakıldığında, boxplot dinamik germede 11,7 ve 11,3. değerinde 2 uç değer (9,17) gösterdi. Uç değer çıkartılarak analiz tekrar yapıldığında, dağılım normal göründü ve uç değer tespit edilmedi. Son olarak Mauchly'nin küresellik testi küresellik varsayımının ihlal edildiğini göstermiştir $\chi^2 = 10.62$, $p < .005$. Bu yüzden serbestlik derecesi Greenhouse-Geisser düzeltmesi ile varsayımın sağlandığı görülmüştür.

Germe protokollerinden sonra katılımcıların çeviklik değerlerinde anlamlı bir gelişme bulundu germesiz protokol (M = 10.206, SD = .474), Dinamik germe protokolü (*M* = 10.094, *SD* = .547) ve statik germe protokolü (*M* = 10.335, *SD* = .585), $F(1.559, 51.463) = 5.88$, $p < 0.05$).

Esneklik

Esneklik, germe çeşitlerinin katılımcıların esneklik değerleri üzerinde anlamlı bir etkisi olmadığını ifade eden üçüncü hipotezi test etmek için Otur ve uzan testi sonrasında ölçüldü. Analizlerden önce, tekrarlı Anovanın varsayımları kontrol edildi. Buna göre, bağımsız değişken normal dağılım gösterdi ve Shapiro-Wilk Testin değeri 0.05 ($p < .05$)'den daha büyük olarak bulundu. Uç değerler açısından bakıldığında, boxplot dağılımları normal göründü ve uç değer tespit edilmedi. Son olarak Mauchly'nin küresellik testi küresellik varsayımının ihlal edilmediğini göstermiştir $\chi 2 = 3.121$, $p > .005$.

Germe protokollerinden sonra katılımcıların esneklik değerlerinde de anlamlı artışlar bulundu. Germesiz protokol (*M* = 34.36, *SD* = 6.26), dinamik germe protokolü (M = 34.84, *SD* = 6.17) ve statik germe protokolü (*M* = 34.74, *SD* = 6.39), $F\ (1.83, 60.39) = 9.11$, $p<0.05$. Bu çalışma sonuçlarına göre, dinamik germe protokolü güreşçilerde çeviklik ve esneklik değerlerinde olumlu etki yaptı. Statik germe ise esneklik değerleri açısından olumlu etki yaptı. Sonuç olarak, antrenörler ve sporcular güç, çeviklik ve esneklik egzersizlerinden önce Dinamik Germe Protokolünü tercih edebilirler.

Tartısma ve Öneriler

Bu çalışmada, germe protokollerinden sonra güçdeki farklılıkları ölçmek için saha testi olarak durarak uzun atlama testi seçildi. Durarak uzun atlama yeteneği kayak zıplama mesafesi ile anlamlı bir ilişki göstermiştir fakat dikey zıplama yeteneği kayak zıplama mesafesi ile anlamsız bir ilişki göstermiştir (Fleck, 1992). Bu durum yatay zıplama yeteneğinin güçte ki gelişmeyi ölçerken dikey zıplama testinden daha üstün bir protokol olabileceği anlamına gelmektedir. Durarak uzun atlama testi geçerli ve güvenilir bir test olduğu rapor edilmiştir (Pinero ve diğ., 2010, Markovic ve diğ., 2004). Ayrca isokinetik güç ile karşılaştırıldığında durarak uzun atlama testis aha testi olarak en uygun kas uygunluk testi olarak görünmektedir (Artero, 2012).

Bu çalışma için birinci hipotez (H_O1) güç değerlerinde germe protokollerinden sonra anlamlı bir farklılık olmayacağını öngörmüştü. Bu çalışmanın sonuçlarına bakılacak olursa germe çeşitlerinden hiç birisi elit güreşçilerin güç değerlerini anlamlı bir şekilde etkilemedi. Bu bakımdan birinci sıfır hipotezi Kabul edildi. Fakat dinamik germe protokolünü takiben yapılan ölçümlerde güreşçilerin güç değerlerinde istatistiksel olarak anlamlı ($p < .05$) olmasa da azda olsa bir artış göstermiştir. Güreşçiler statik germeye kıyasla dinamik germe protokolünden sonra daha iyi performans göstermişlerdir.

Bazı çalışmalar dinamik germeden sonra güç ölçümü olarak zıplama performansı üzerinde anlamlı bir etki gösterdi. Reiman ve diğ., (2008) kuadriseps zirve tork üretiminde statik germenin etkisini araştırdıktan sonra üniversite öğrencilerinin güç değerlerinde germe çeşitleri açısından anlamlı bir etki bulmadı. Otuz saniye süren germe protokolünden önce ve sonra katılımcıların değerlerinde anlamlı bir farklılığa ulaşmadılar. Bizim çalışma sonuçlarımıza paralel olarak, Christensen ve Nordstrom, (2008) güç üzerine çalıştılar ve dikey zıplama performansının dinamik germe protokolü tarafından etkilenmediğini buldu. Zourdos, (2012) elit sporcularda dayanıklılık ve koşu enerji maliyeti üzerinde dinamik germenin etkisini araştırdı ve sonuçlarına göre, elit antrenmanlı sporcularda dinamik germe protokolünün koşu dayanıklılık performansını etkilemediğini buldu.

Bizim çalışmanın bulgularına zıt olarak, birçok çalışma dinamik germe protokolünün güç değerlerinde faydalı sonuçlar verdiğini ortaya çıkarmıştır. Yamaguchi ve arkadaşları (2007) ısınma bölümünde yapılan dinamik germe egzersizlerinin gücü geliştirdiğini gösterdi. Bununla beraber, Colak (2012) dinamik germe protokolünün eklemin hareket menzili ve kas kuvvetinde olumlu etkileri olduğunu ifade etti. Gourgoulis ve diğ., (2003) güçlü ve iyi antrene olmuş kişilerde dinamik germe artan zıplama mesafesi gibi önemli oranda performans getirisi olduğunu açıkladı. Buna benzer olarak, Yamaguchi & Ishii (2005) 15 tekrarlı 5 alt vücut germesini içeren dinamik germeden sonra bacak pres testinde güç değerlerinde anlamlı bir artış buldu. Ayrıca, güç performanslarından önce dinamik germe ve statik germe içeren germe protokolleri farklı katılımcı guruplarında araştırıldı. Genç katılımcılar da benzer sonuçlar gösterdi. Faigenbaum ve diğ., (2005) yüksek güç çıktısı gerektiren hareketlerin performansından önce, çocukların orta ve yüksek yoğunlukta dinamik germe protokollerini uygulamaları önerildi.

Statik germe müsabık sporcuların performanslarında olumsuz veya etkisiz etkilerinden dolayı bilim insanları ve meslek adamları tarafından eleştiriliyor. Bizim çalışma sonuçlarımıza göre statik germe dinamik germe ve germe olmayan protokolle karşılaştırıldığında güç üzerinde anlamlı bir etkiye ulaşmadı. Fakat katılımcılar statik germeden sonra germe olmayan protokole göre biraz daha iyi performans gösterdiler ve dinamik germeden biraz daha düşük skorlara ulaştılar. Genel olarak, statik germenin güç üzerindeki etkisi anlamlı değildi. Bu bakımdan, Yamaguchi ve diğ., (2005) 30 sn statik germenin kassal performansı ne geliştirdiğini ve ne de azaltığını, ve dinamik germenin kassal performansı geliştirdiğini açıkladılar. Little ve diğ., (2006) statik germe atletik performans zararlı olmadığını ifade etti. Bunlara terz olarak, literatürde statik germenin bazı faydalarının ortaya çıkartıldığı ifade edilmiştir. Carter ve diğ., (2008) statik germe egzersizlerinin tork üretiminde kapsamlı bir artış sağladığını açıkladılar.

Hali hazırda mevcut olan delillere göre, germe protokollerinin sporcuların performans çıktılarını etkileyebileceğini söylemek adil olacaktır. Bazen bazı sporların performans ve skorlarında küçük olumlu artışlar ve farklar müsabakanın sonuçlarını değiştirebilecek büyük bir etkiye sahip olabilir. Bu yüzden, ısınma bölümündeki germe protokolü her bir sporun gereksinimleri ve ihtiyaçları doğrultusunda sporcuların ihtiyaçları ile tutarlı olmalıdır. Literatür dinamik germe protokollerinin sprint ve zıplama gibi güç ile ilgili performansları geliştirebildiğini göstermektedir. Bu araştırmacılara göre, hız ve güç aktivitelerinden önce aktivite öncesi germe protokolü olarak dinamik germe kullanılmalıdır. Bu tavsiye Fletcher & Jones (2004) ve Young & Behm (2003) çalışmalarının sonuçları tarafından desteklenmiştir.

Appendix T

TEZ FOTOKOPİSİ İZİN FORMU

ENSTİTÜ

Fen Bilimleri Enstitüsü	☐
Sosyal Bilimler Enstitüsü	X
Uygulamalı Matematik Enstitüsü	☐
Enformatik Enstitüsü	☐
Deniz Bilimleri Enstitüsü	☐

YAZARIN

Soyadı : ÇELEBİ
Adı : Murat
Bölümü : Beden Eğitimi ve Spor

TEZİN ADI (İngilizce): The effects of dynamic and static stretching protocols on power, agility and flexibility in elite wrestlers.

TEZİN TÜRÜ : Yüksek Lisans ☐ Doktora X

1. Tezimin tamamından kaynak gösterilmek şartıyla fotokopi alınabilir. ☐
2. Tezimin içindekiler sayfası, özet, indeks sayfalarından ve/veya bir bölümünden kaynak gösterilmek şartıyla fotokopi alınabilir. X
3. Tezimden bir (1) yıl süreyle fotokopi alınamaz. ☐

TEZİN KÜTÜPHANEYE TESLİM TARİHİ: