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Effects of Static Stretching on Muscular Power

in Female Collegiate Soccer Players

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Effects of Static Stretching on Muscular Power

in Female Collegiate Soccer Players

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Abstract

Current literature over the effects of static stretching on muscular power is inconsistent. A better understanding of the effects of static stretching could help improve athletic performance. The purpose of this study was to determine the acute and delayed effects of static stretching on muscular power performance in female collegiate soccer players. The participants were healthy, uninjured volunteers who were soccer players from the University of Central Oklahoma women's soccer team (n = 13). Each participant was led through a dynamic only stretching condition and a combination stretching condition. The focus of the stretching conditions was the large muscle groups of the lower body. The two stretching conditions were completed on nonconsecutive days in the same week. Following the stretching condition, the participant completed three trials of a countermovement jump (CMJ), three trials of a instep kick, and two trials of the Illinois Agility Test (IAT) for the acute testing. The participants then had a 30-minute rest period followed by another round of CMJ, instep kicking, and IAT trials to complete the delayed testing. Dependent t-tests were completed to compare the acute and delayed testing of the dynamic only and combination conditions. The results indicated non-significant differences between the acute dynamic only stretching condition and combination stretching conditions, as well as between the delayed dynamic only stretching condition and combination stretching condition ($p < .05$). Researchers concluded that there is no significant effect of static stretching on muscular power performance in female collegiate soccer players. Although the calculated effect sizes of the study did show trends of static stretching having a positive effect on muscular power for all variables except for acute CMJ heights and acute and delayed IAT performance. Future research should assess the effects of static stretching on muscular power in larger sample size of female and male collegiate soccer players.

Chapter One: Introduction

Significance

Stretching is considered an essential component of the pre-activity warm-up. Static stretching has been the most commonly used stretching technique for many decades (Behm & Chaouachi, 2011). During those decades, the warm-up consisted of submaximal aerobic activity (such as jogging or biking) followed by static stretching (Behm & Chaouachi, 2011). Static stretching involves the lengthening of the muscle fibers by moving the limb close to its end range of motion then holding the position for up to two minutes (Clark, O'Leary, Hong, & Lockard, 2014). Multiple studies have shown static stretching can increase the range of motion (ROM) at a joint (Donti, Tsolakis, & Bogdanis, 2013; Marek et al., 2005; Samson, Button, Chaouachi, & Behm, 2012; Tsolakis & Bogdanis, 2012; Wong, Chaouachi, Lau, & Behm, 2011).

Studies recently have also shown static stretching could potentially impair athletic performance (Behm & Chaouachi, 2011; Wong et al., 2011). Impairments to explosive jumping and sprinting are often observed when the total duration of static stretching is ≥ 90 seconds (Behm & Chaouachi, 2012). In contrast, dynamic stretching has been observed to facilitate explosive movements, sprints, jumps, and muscular power output (Clark et al., 2014; Wong et al., 2011). Dynamic stretching is the act of moving the joint quickly through its range of motion with little resistance (Fredrick & Szymanski, 2001). Dynamic stretching is thought to raise muscle and core body temperature, elongate active muscles, decrease the inhibition of antagonist muscles, stimulate the nervous system, and decrease risk of injury (Fredrick & Szymanski, 2001). Studies that combine type of stretching report conflicting results with both impediments in jump height and sprint performance (Tsolakis & Bogdanis, 2012). Conversely, Wong et al. (2011) reported there were no adverse effects to vertical jump and sprint performance. Based on the conflicting evidence, it is unclear if there is an appropriate or optimal combination and duration of static and dynamic stretching to use prior to physical activity or athletic competition (Wong et al., 2011).

Many sports rely on muscular strength and muscular power especially at higher levels of competition (Lopez-Segovia, Marques, Tillaar, & Gonzalez-Badillo, 2011). Individuals who play soccer use lower body power in order to stop, change direction, and change running speeds (Lopez-Segovia et al., 2011, Yamaaguchi, Ishii, Yamanaka, & Yasuda, 2006). Muscular power can be measured using different laboratory and field tests. These tests included explosive jumping, isometric leg extension, sprints, or a combination of tests. The Fitro Dyne Tendo unit is also a reliable and valid measure of muscular power (Jennings, Viljoen, Durandt, & Lambert, 2005). Many studies have been conducted using soccer players of all levels. However, a limited number of those studies use female athletes as participants (Brooks, Clark, & Dawes, 2013). Normative data for women is limited especially in physical and kicking performance (Brooks et al., 2013). According to available literature, no study has been conducted to determine the effects of combined static and dynamic stretching on muscular power in female collegiate soccer players. In this study muscular power was determined by using the countermovement vertical jump, Illinois Agility Test, and a Tendo unit measuring instep kick power.

Purpose

The purpose of this study is to determine the acute and delayed effects of static stretching on muscular power performance in female collegiate soccer players. The participants were 13 NCAA Division II female soccer players from the University of Central Oklahoma. Athletes with a history of any lower extremity surgeries or fractures in the past twelve months were excluded from the study. The participants were randomly assigned to one of two testing orders (based on week tested) but every participant would experience each stretching condition. The two conditions were dynamic stretching only or a combination condition that was dynamic stretching followed by static stretching. The dynamic stretching protocol was the same for each participant. The static and dynamic stretching protocols were shown to the participants by the lead researcher. Both designed programs stretched each of the major muscle groups of the lower extremities. These muscle groups included the gluteals, hip adductors, hamstrings, quadriceps, and calf muscles. The complete dynamic stretching protocol can be found in Appendix A. The complete static stretching protocol can be seen in Appendix B. Once the participant completed their groups' stretching program, they were asked to perform the muscular power tests. The Illinois Agility Test (IAT), countermovement vertical jump (CMJ), and instep kick were used to determine each participant's muscular power. Every participant underwent immediate and delayed measurements for each test. The delayed test measurements occurred 30 minutes after the immediate test measurements.

The independent variable of the study was the type stretching protocols, either dynamic only condition or combination condition. The dependent variable assessed in this study was muscular power performance. The hypothesis of this study is the participants would produce faster Illinois Agility Test results, higher vertical jump results, and better scores for instep kick power after the dynamic stretching only condition compared to the combination stretching condition. The hypothesis is based on studies comparing static and dynamic stretching effects on muscular power output. Multiple research studies have observed acute bouts of static stretching could cause deficits in muscular performance (Amiri-Khorasani & Kellis, 2013; Marek et al., 2005; Samson, Button, Chaouachi, & Behm, 2012). Whereas, researchers have observed dynamic stretching has the potential to improve performance in sprints, explosive movements, jumps, and power output (Clark, O'Leary, Hong, & Lockard, 2014; Wong et al., 2011).

Limitations and Delimitations

A limitation of this study was the use of the Tendo as a way to determine soccer-specific kicking power. The Tendo unit has not been confirmed to be a reliable and valid way to test for muscular power in multi-plane movement such as an instep soccer kick. Also, the results of the study can only be generalized to the dynamic and static stretching protocols used in the study. A limitation was the effort put forth by the participant; not all participants might have put forth full exertion for each test trial. The weather was another limitation of the study. Lastly, the inability to reach the ideal sample size was a limitation of this study.

A delimitation of the study will be the type of participant. The participants were current Division II female, collegiate soccer players with no history of fractures or surgeries to the either of their lower extremity in the past twelve months. All participants underwent the same dynamic and static stretching protocol regardless of their test group. The stretching protocols will be a delimitation of the study. The same researcher gave the instructions for the stretching protocols to each participant. The same procedures/instructions were used by all of the student assistants during the muscular power tests (Appendix C). In addition, the same equipment was used to measure muscular power in each participant throughout all acute and delayed tests.

Definition of Terms

- Dominant leg: The athlete's preferred leg used to kick the ball (Brooks et al., 2013).
- Instep kick: a kick used to produce the most power, such as taking a shot (Brooks et al., 2013).

- Tendo unit: a unit that attaches to conventional resistance-training equipment and measures the speed of muscle contraction. The unit can calculate muscular power. (Jennings et al., 2005).
- Static Stretching: The lengthening of the muscle fibers by moving the limb close to its end range of motion then holding the position for up to two minutes (Clark, et al., 2014).
- Dynamic Stretching: The act of moving the joint quickly through its range of motion with little resistance (Fredrick & Szymanski, 2001).
- Range of motion: The total motion available to a joint as determined by the way of bones that make up that joint move in a specific direction (Frederick & Frederick, 2006).
- Active range of motion: the degree to which a joint can be moved by a muscle contraction (Prentice, 2009).
- Passive range of motion: the degree to which a joint may be passively moved to the endpoints in the range of motion (Prentice, 2009).

Chapter Two: Literature Review

Stretching is a common technique included in pre-activity warm-ups for beginner, intermediate, and elite athletes. Stretching is traditionally used to increase flexibility or range of motion about a joint to enhance performance and/or reduce risk of injury during a chosen activity (Marek et al., 2005). The purpose of the warm-up is to stimulate blood flow to the body's muscles and tendons improving their suppleness and ultimately increasing the body's temperature and coordinated movement (McMillian, Moore, Hatler, & Taylor, 2006). Two frequently used types of stretching during pre-activity warm-ups are static and dynamic techniques. Static stretching involves the lengthening of the muscle fibers through a stretch torque then holding the lengthened position for up to two minutes (Clark et al., 2014). Whereas, dynamic stretching is repetitively moving the limb from the neutral position to its end range then back to neutral in a smooth, controlled manner (Clark et al., 2014). Static stretching has been a staple in pre-activity warm-ups for many years. However, recent researchers have stated acute bouts of static stretching could cause deficits in muscular performance (Amiri-Khorasani & Kellis, 2013; Marek et al., 2005; Samson, Button, Chaouachi, & Behm, 2012). Conversely, dynamic stretching has been identified to potentially improve performance in sprints, explosive movements, jumps, and power output (Clark et al., 2014; Wong, Chaouachi, Lau, & Behm, 2011). Power output was a variable often studied in regards to stretching. Muscle power output is an important factor that affects many different sport performances (Yamaguchi, Ishii, Yamanaka, & Yasuda, 2006). The following literature review will analyze the effects of acute bouts of static and dynamic stretching on power output. Various tests were used to measure power output. The different types of power output tests used were explosive jumping, isometric leg extension, sprints, change of direction, or a combination of tests.

Comparisons of Static and Dynamic Effects on the Power Output Variable Using Different Tests

Explosive jump tests. The first type of tests to measure power output addressed are the countermovement jump and squat tests. The participant performed the countermovement jump (CMJ) beginning in an extended leg position; he or she then lowers to a squat position followed by an explosive movement off the ground (Chtourou, Aloui Hammouda, Chaouachi, Chamari, & Souissi, 2013). During the squat jump (SJ), the participant begins in a squatted position, briefly pausing, then jumps off the ground as high as possible (Chtourou et al., 2013). Three studies (Chtourou et al., 2013; Donti, Tsolakis, & Bogdanis, 2014; Tsolakis & Bogdanis, 2012) determined the effects of acute stretching on power output through explosive jumps test. There were similarities within the three listed studies. First, each study used athletes for the participants. Donti et al. (2014) and Tsolakis and Bogdanis (2012) used highly trained male and female athletes: whereas Chtourou et al. (2013) used only male participants. In addition to testing for stretching effects on power output, two of the studies tested for stretching effects on range of motion (ROM) of the dominant leg's hip joint (Donti et al., 2014; Tsolakis & Bogdanis, 2012).

The procedures of the listed studies were comparable. Each study determined a baseline for each dependent variable after 5 minutes of jogging as a warm-up (Chtourou et al., 2013; Donti et al., 2014; Tsolakis & Bogdanis, 2012). The muscle groups selected for static stretching were the same for each study; every researcher chose to stretch the calf, hamstring group, and quadriceps group (Chtourou et al., 2013; Donti et al., 2014; Tsolakis & Bogdanis, 2012). The muscle groups were stretched until the participant had mild discomfort in the muscle (Chtourou et al., 2013; Donti et al., 2014; Tsolakis & Bogdanis, 2012). The static stretching procedure was identical between two of the studies for each muscle group (Donti et al., 2014; Tsolakis & Bogdanis, 2012). Each stretch was done unilaterally while the participant stood (Donti et al., 2014; Tsolakis & Bogdanis, 2012). Stretching the quadriceps was achieved when the participant grabbed his or her ankle and brought it towards the buttocks (Donti et al., 2014; Tsolakis & Bogdanis, 2012). The participant stretched the hamstring group when he or she placed the heel of an extended leg on a structure below hip level and bent forward (Donti et al., 2014; Tsolakis & Bogdanis, 2012). Lastly, the participant stretched the calf by standing 1 meter from a wall with his or her foot planted on the ground, then the participant leaned forward (Donti et al., 2014; Tsolakis & Bogdanis, 2012). The Chtourou et al. (2013) study differed by having the clinician stretch the participants' muscle groups. The calf and hamstring groups were stretched in supine lying position and the quadriceps groups were stretched in a prone lying position (Chtourou et al., 2013).

The dependent variables for two of the studies were the same: CMJ performance and hip ROM (Donti et al., 2014; Tsolakis & Bogdanis, 2012). Instead of hip ROM, Chtourou et al. (2013) used SJ as a second dependent variable. In addition, the Chtourou et al. (2013) study observed diurnal variation of CMJ and SJ; each participant performed a CMJ and SJ in the morning (07:00) and in the evening (17:00). The Chtourou et al. (2013) study differed the most in the procedures portion of the study compared to the other studies (Donti et al., 2014; Tsolakis & Bogdanis, 2012).

For instance, the participants were divided into three groups: no stretching, static stretching, and dynamic stretching (Chtourou et al., 2013). The participants only performed one type of stretching at a time in the study conducted by Chtourou et al. (2013), whereas in the other two studies the participants performed static followed by dynamic stretching (Donti et al., 2014;

Tsolakis & Bogdanis, 2012). In Chtourou et al., (2013), CMJ and SJ measurements were determined for each of the three groups. The static stretches for each muscle in the three studies were held for various time periods: three repetitions for 20 seconds (Chtourou et al., 2013), one repetition for either 15 seconds (short group) or 45 seconds, long group (Tsolakis & Bogdanis, 2012), one repetition of either 15 seconds (short group) or 30 seconds, long group (Donti et al. 2014). In the studies conducted by Donti et al. (2014) and Tsolakis and Bogdanis (2012), a ROM and CMJ measurement followed static stretching. Dynamic stretching followed the measurement; tuck jumps were the dynamic intervention (Donti et al., 2014; Tsolakis & Bogdanis, 2012). The number of tuck jumps varied depending on whether the participant was in the short or long stretch group (Donti et al., 2014; Tsolakis & Bogdanis, 2012). The long stretch group in Donti et al. (2014) completed 3 sets of 5 repetitions and the short group competed 5 total tuck jumps. In comparison, the long stretch group in Tsolakis and Bogdanis (2012) executed 3 sets of 5 repetitions and the short stretch group completed 3 sets of 3 repetitions.

The Chtourou et al. (2013) study concluded static stretching was detrimental and dynamic stretching was beneficial on the participants jumping performance. Static stretching was observed to decrease the CMJ and SJ height significantly ($p < 0.01$) both in the morning and evening compared to the no stretching group (Chtourou et al., 2013). But, dynamic stretching significantly ($p < 0.01$) increased the CMJ and SJ height, both morning and evening, compared to the no stretching group (Chtourou et al., 2013). Donti et al. (2014) and Tsolakis and Bogdanis (2012) had differing results compared to Chtourou et al. (2013) and one another. Countermovement jump height was unchanged in both the short stretch groups (Donti et al., 2014; Tsolakis & Bogdanis, 2012). Though in the long stretch group, the results were the opposite when compared between the studies (Donti et al., 2014; Tsolakis & Bogdanis, 2012).

The CMJ height had a significant increase (4.6 ± 0.9%, $p = 0.012$) after the long static stretching, but had returned to baseline 8 minutes after the tuck jumps (Donti et al., 2014). In the Tsolakis and Bogdanis (2012) study, the CMJ height significantly decreased (5.5 ± 0.9%, $p < 0.01$) after the long static stretching but returned to baseline after the tuck jumps. Tsolakis and Bogdanis (2012) concluded lower limb power may decrease after long static stretching but dynamic intervention may reverse the negative effects. Overall, static stretching caused negative effects on jump performance when the static stretch was held for equal to or longer than a total of 45 seconds but no significant effects when held for 15 seconds (Chtourou et al., 2013; Donti et al., 2014; Tsolakis & Bogdanis, 2012). The dynamic only condition and static stretching followed by dynamic stretching condition (one repetition for 30 seconds) were the only two conditions from the three studies where jump performance increased significantly (Chtourou et al., 2013; Donti et al., 2014).

Isometric leg extension tests. Power output was measured using maximal voluntary contraction (MVC) for isometric leg extensions in two studies (Behm et al., 2006; Yamaguchi et al., 2006). Neither of the studies had any type of dynamic stretching intervention (Behm et al., 2006; Yamaguchi et al., 2006). There were more differences between the listed studies than similarities. For example, the Behm et al. (2006) study consisted of two experiments. The purposes of the two experiments were to determine if a relationship existed between joint ROM (flexibility) and acute stretch-induced changes, also whether a four-week flexibility program would reduce static stretch-induced impairments (Behm et al., 2006). The first experiment was a correlation study conducted with 18 participants (9 females, 9 males, age; 25 ± 8.3 years); each participant was tested for maximal voluntary isometric contraction (MVIC) of knee extension and drop jump before and after an acute bout static stretching (Behm et al., 2006).

The second experiment was a longitudinal repeated measures design with each participant being tested for knee extension and flexion MVIC, drop jump test, and CMJ test before and after an acute bout of static stretching (Behm et al., 2006). The repeated measures experiment had 12 male participants (age; 21.9 ± 2.1 years); the experiment lasted 4 weeks with the flexibility training occurring 5 days a week for the lower limbs (Behm et al., 2006). The acute bouts of static stretching were for the quadriceps group, hamstring group, and calf group (Behm et al., 2006). Each stretch was held for 30 seconds for 3 repetitions with a 30 second recovery between each repetition (Behm et al., 2006). All dependent variable were significantly impaired post-static stretching: knee extension (-6.1% to -8.2%; $p < 0.05$), knee flexion (-6.6% to -10.7%l $p < 0.05$), MVIC and drop jump contact time (5.4% to 7.4%; $p < 0.01$), and CMJ height, -5.5% to -5.7%; $p < 0.01$, (Behm et al., 2006). Behm et al. (2006), determined there was not a significant relationship between ROM and stretch-induced deficits (Behm et al., 2006).

In the second study, the 12 male participants (23.8 ± 2.3 years) were divided into two intervention groups: a non-stretching group (20 minute rest) and a static stretching group (Yamaguchi et al., 2006). Only the right leg extensors were stretched in Yamaguchi et al. (2006) study using 3 assisted stretches and 3 unassisted stretches. The total time for stretching was 20 minutes; there were 4 repetitions of 30 seconds for each stretch with 20 seconds rest in between the repetitions (Yamaguchi et al., 2006). Each participant’s maximal voluntary concentric torque was measured before and after the intervention (Yamaguchi et al., 2006). The peak power output was observed to be significantly ($p < 0.05$) lower after static stretching in comparison to non-stretching intervention. Yamaguchi et al. (2006) concluded static stretching decreases power performance. Even though, Behm et al. (2006) and Yamaguchi et al. (2006) had differing experiment procedures, they each observed a significant decrease in maximal voluntary contraction power output after static stretching interventions.

Sprint performance and change of direction test. One study used repeated sprint ability (RSA) and change of direction (COD) tests to measure muscular power and performance (Wong et al., 2011). Wong et al. (2011) compared the effects of different durations of static stretching followed by dynamic stretching on RSA and COD performance. Twenty-five participants each performed the RSA and COD tests in randomized order per static stretch duration (Wong et al., 2011). The static stretch total durations were 30 seconds, 60 seconds, and 90 seconds (3 stretches x 10 s, 20 s, and 30 s) followed by a total of 90 seconds of dynamic stretches, 3 stretches x 30 s (Wong et al. 2011). The calf, hamstring, and quadriceps group were the chosen muscle groups stretched during this study (Wong et al., 2011). The quadriceps and calves were stretched in the same manner as in the Donti et al. (2014) and Tsolakis and Bogdanis (2012) studies. The participants leaned the upper torso forward towards the ground while keeping his or her legs extended stretched the hamstring group (Wong et al., 2011). The dynamic stretches were chosen to stretch the same muscle groups as the static through high knee lifts, buttock kicks, and straight leg skipping (Wong et al., 2011).

The procedure sequence for testing was a flexibility test (sit-and-reach test), static stretching, dynamic stretching, second flexibility test, 2 minute rest period, RSA or COD test, and lastly a third flexibility test (Wong et al., 2011). The duration of static stretching had a significant ($p < 0.001$) positive effect on flexibility with 36.3% and 85.6% greater sit-and-reach scores for 60 seconds and 90 seconds static stretch duration, respectively (Wong et al., 2011). However, there was no significant difference in RSA and COD scores for the three stretch conditions (Wong et al., 2011). The combination of static and dynamic stretching did not adversely effect or facilitate RSA or COD performance (Wong et al., 2011). Wong et al. (2011) stated the lack of impairment or facilitation could have been due to a counterbalancing of possible static stretching impairments and dynamic stretching facilitation.

The acute effects of different stretching methods were the focus of one study. The Illinois Agility Test (IAT) was the specific change of direction test used in the study (Amiri-Khorasani, Sahebozamani, Tabrizi, & Yusof, 2010). The purpose of the study was to determine the acute stretching effects on performance of soccer players in the IAT (Amiri-Khorasani et al., 2010). Four stretching conditions were used in the study; these conditions were dynamic, static, combination of static and dynamic and no stretching (Amiri-Khorasani et al., 2010). Nineteen professional male soccer players (age = 22.5 ± 2.5 years, height = 1.79 ± 0.003 m, body mass = 74.8 ± 10.9 kg) participated in the study (Amiri-Khorasani et al., 2010). They were asked to perform the IAT after different warm-ups, which consisted of the four stretching conditions (Amiri-Khorasani et al., 2010). The participants were divided into four groups with each group performing the four different warm-up protocols on four nonconsecutive days (Amiri-Khorasani et al., 2010). The warm-up protocol consisted of a four-minute jog followed by one of the stretching conditions then a two-minute rest, the participants ended with performing the IAT (Amiri-Khorasani et al., 2010).

The principal leg muscle groups (gastrocnemius, hamstrings, quadriceps, gluteals, adductors, and abductors) were stretched in the stretching conditions (Amiri-Khorasani et al., 2010). The static stretches were held for 30 seconds on one leg before changing to stretch the other leg (Amiri-Khorasani et al., 2010). The participants were told to stretch until they approached the end of the range of motion but within their pain threshold (Amiri-Khorasani et al., 2010). The dynamic stretching was performed on alternate legs for 60 seconds at a rate of approximately one stretch cycle every two seconds or unilaterally for 30 seconds, then repeated on the other leg at a rate of one stretch cycle every second (Amiri-Khorasani et al., 2010). The dynamic stretches included a backward reach run, lateral lunge, drop lunge, a straight leg march, and a heel-to-toe walk (Amiri-Khorasani et al., 2010). The participants were told to try to attain full range of motion for each dynamic stretch (Amiri-Khorasani et al., 2010). A significant decrease in agility time was observed after the no stretching condition when comparing no stretching or static stretching (Amiri-Khorasani et al., 2010). Likewise, a significant decrease in agility time was observed after dynamic stretching when comparing dynamic to static stretching and dynamic to combined stretching (Amiri-Khorasani et al., 2010). The mean ± SD data were 14.18 ± 0.66 seconds (no stretch), 14.90 ± 0.38 (static), 13.95 ± 0.32 seconds (dynamic), and 14.50 ± 0.35 seconds (combined). The researchers concluded dynamic stretching during the warm-up was most effective in preparing individuals for agility performance (Amiri-Khorasani et al., 2010). They also concluded that static stretching does not appear to be detrimental to agility performance when combined with dynamic stretching for professional soccer players (Amiri-Khorasani et al., 2010).

Combination of power output tests. Multiple tests were used to measure power output in the study conducted by Samson et al. (2012). The participants were tested for movement time (kicking leg over 0.5 m distance), CMJ height, sit-and-reach flexibility, and 20-meter sprints (Samson et al., 2012). The 19 participants (9 male; 27.8 ± 8.4 years and 10 female; 22.2 ± 3.3 years) were required to complete four warm-up conditions: general warm-up with dynamic stretch, general and specific warm-up with dynamic, general warm-up with static stretch, and general and specific warm-up with static stretch (Samson et al., 2012). The general warm-up consisted of a run around a 200-meter track at 70% of the participant’s maximal hear rate

(Samson et al., 2012). The dynamic stretch included 3 sets of 30 seconds each of hip extension/flexion, adduction/abduction with fully extended legs, trunk circles, and passive ankle rotation (Samson et al., 2012). The sport specific involved high knee skips, high knee runs, and butt kicks; each exercise was during a 20-meter sprint (Samson et al., 2012). The participants stretched their quadriceps, hamstrings, calves, and low back for 3 sets of 30 seconds to mild discomfort for the static stretching intervention (Samson et al., 2012). The performance tests were conducted in the same order for each participant: movement time, CMJ, sit-and-reach flexibility, and repeated sprints (Samson et al., 2012).

The performance tests were conducted prior to the warm-up and 3 minutes after the warm-up conditions (Samson et al., 2012). No significant ($p < 0.05$) main effects were observed for CMJ and movement time for any of the warm-up conditions (Samson et al., 2012). Significant effects were observed for the sit-and- reach flexibility ($p = 0.0083$) and sprint ($p = 0.0013$) performance tests (Samson et al., 2012). Static stretching conditions improved flexibility by an average of 2.8% compared to dynamic stretching conditions (Samson et al., 2012). Sprint performance times were significantly lower (0.94%) during sport-specific conditions compared to the conditions without sport-specific warm-ups. Overall, dynamic and static stretching were not the most influential variables for performance in the study conducted Samson et al. (2012); instead sport-specific warm-ups enhanced sprint performance.

Instruments

Tendo Weightlifting Analyzer. The aim of the study was to quantify the repeatability of the measurement speed of movement, from which muscle power is calculated (Jennings et al., 2005). The Tendo unit was used during three trials of squat jumps and bicep curls. Thirty male subjects were asked to perform three squat jumps and three bicep curls at six differing loads, with a rest in between each exercise (Jennings et al., 2005). The six differing loads were 0%, 20%, 40%, 60%, 80%, and 90% of the participants' 1RM (Jennings et al., 2005). The 1RM were determined during the familiarization stage on day 1. The upper body and lower body maximum power was predicted from the force-velocity curves derived from the range of weights used for each trial (Jennings et al., 2005). Maximum power measurements of squat jump and biceps curl had intraclass correlation coefficients of $r = 0.97$ and $r = 0.97$ (Jennings et al., 2005). In conclusion, muscular power can be measured with a high degree of reliability with FitroDyne (Jennings et al., 2005).

Countermovement Vertical Jump. The purpose of the study was to determine the reliability and factorial validity of squat jump and countermovement jump (Markovic, Dizdar, Jukic, & Cardinale, 2004). Physical education students (n =93) performed 7 explosive power tests, 5 vertical jumps and 3 horizontal jumps (Markovic et al., 2004). Each participant was allowed 3 trials of each test (Markovic et al., 2004). The CMJ vertical jump was tested for reliability and factorial validity against the squat jump, Sargent jump, and the Abalakow's jump with and without arm swings (Markovic et al., 2004). The study determined the CMJ test had the highest reliability ($\alpha = 0.98$) of all the tests. The factorial validity for the CMJ test was also the highest compared to the other tests, $r = 0.87$ (Markovic et al., 2004).

Illinois Agility Test. The purpose of the study was to assess the reliability and criterion-related validity of the change of direction Illinois Agility Test (COD IAGT), as well as to determine whether a relationship with power and speed exists (Hachana et al., 2013). The study compared the COD IAGT to the T_{test}, the countermovement jump, and 30-m sprint performance (Hachana et al., 2013). The participants consisted of 105 male (age: 20.82 ± 1.31 years; height: 180 ± 7 cm; body mass: 72.33 ± 8.75 kg; fat mass 20.18%) sports science students (Hachana et al., 2013). The study occurred in three phases. The first phase was to analyze the absolute and relative reliabilities of the COD IAGT in a random group of 89 of the 105 participants (Hachana et al., 2013). In phase one, the test was performed for three trials with a three-minute rest period between each trial over the course of two separate days (Hachana et al., 2013). The second phase analyzed the criterion-related validity of the COD IAGT was determine by looking at its correlation to the T_{test} using the "Pearson" moment correlation in all 105 participants (Hachana et al., 2013). During a single day, the COD IAGT and T_{test} tests were performed for three trials with three-minute rest periods (Hachana et al., 2013). The different test sessions were separated by a 30-minute rest period to limit the likelihood of fatigue (Hachana et al., 2013). The third phase analyzed the relationships between the COD IAGT and acceleration, maximum speed, and the vertical jump performance in the 105 participants (Hachana et al., 2013). The tests were performed in triplicate with a minimum of three minutes of rest between each trial (Hachana et al., 2013).

The COD IAGT was observed to have acceptable relative and absolute reliability (Hachana et al., 2013). The intraclass correlation coefficient and the *SEM* for the COD IAGT test were 0.96 (95% CI, 0.85-0.98) and 0.19 seconds (Hachana et al., 2013). The COD IAGT and T_{test} were significantly correlated (r = 0.31 [95% CI, 0.24-0.39]; p < .05). Acceleration and COD IAGT were observed to not be associated through Pearson moment correlation (Hachana et al., 2013). Significant correlations were observed between COD IAGT and leg power (r = -.39 [95% CI, -0.26 to -0.44]; p < .05), and speed (r = 0.42 [95% CI, 0.37-0.51]; p < .05). When the researchers controlled for speed with partial correlation, the significant relationship between leg power and COD IAGT disappeared (Hachana et al., 2013). Therefore, the researchers concluded

COD IAGT seems to be a reliable and valid test, whose performance is significantly related to speed (Hachana et al., 2013).

Summary

A considerable amount of research has been carried out over the subject of stretching and its effects on performance and power output. Studies have compared acute bouts of static stretching to non-stretching groups (Amiri-Khorasani et al., 2010; Behm et al., 2006; Yamaguchi et al., 2006). Other studies have compared static stretching to dynamic stretching and/or a combination of both types of stretching (Amiri-Khorasani et al., 2010; Chtourou et al., 2013; Donti et al., 2014; Tsolakis & Bogdanis, 2012; Wong et al. 2011; Samson et al., 2012). The only order of combination conditions consisted of static stretching followed by dynamic (Donti et al., 2014; Tsolakis & Bogdanis, 2012; Wong et al., 2011; Amiri-Khorasani et al., 2010). Research is needed comparing static, dynamic, and non-stretching groups; only one study in the above listed literature compared all three (Chtourou et al., 2013). Different tests were used to measure performance and power output, the most common test to measure lower limb muscular power was the countermovement jump. Even in studies using the same test to evaluate power and performance, results were not all the same. Some research concluded static stretching was detrimental to muscular power output and performance (Chtourou et al., 2013; Behm et al., 2006; Yamaguchi et al., 2006). Whereas, Wong et al. (2011) concluded static or dynamic stretching did not have any effect on repeated sprint ability or change of direction during the study. Two studies, Donti et al. (2014) and Tsolakis and Bogdanis (2012) that were extremely similar had differing results in regards to effects of static stretching on CMJ. More research is needed to provide a common consensus about the effects of acute bouts of static and dynamic stretching, especially when combined.

Chapter Three: Methodology

The purpose of this study is to determine the acute and delayed effects of static stretching on power output performance in female collegiate soccer players.

Participants

The participants of the study were current female NCAA Division II level college soccer athletes from the University of Central Oklahoma. Written documentation was provided to the lead researcher by the University of Central Oklahoma's head soccer coach granting permission to recruit the women's soccer team to participate in the study (Appendix D). Recruitment began upon approval from the Institutional Review Board (Appendix E). Recruitment occurred through a spoken announcement to the women's soccer team by a member of the researcher's committee. The researcher did not make the announcement to prevent biases due to the researcher working as a Graduate Assistant in the Athletic Training department at the university. At the recruitment meeting, the participants were informed of the risks and benefits of participating in this study. All participants signed the informed consent form (Appendix F) and completed an injury history questionnaire. The questionnaire was designed by the lead researcher to determine the eligibility of the participant to take part in this study (Appendix G).

The estimate sample size was 15 total participants to find significance with an alpha level of .05 and a desired power of 0.83 (Chtourou et al., 2013). The estimated sample size is based on a power analysis using the data from Chtourou et al. (2013), which produced a .62 effect size when comparing static and dynamic stretching effects on vertical jump performance. Eighteen individuals volunteered for the study but only 13 were able to complete the study. Four individuals did not qualify for participation due to their injury history and one individual was unable to participate due to a scheduling conflict. All the participants were volunteers who had not sustained any lower extremity fractures in the past twelve months. Also, persons who had undergone a surgery to either lower extremity within the past twelve months were excluded. History of injury was an exclusion factor because the injury could change the performance of the participant during the muscular power tests. Each participant was be cleared to perform physical exertion through a pre-participation physical exam, which is already a requirement of the individual to compete as a collegiate student-athlete.

Instruments

Illinois Agility Test. The study measured muscular power of the lower extremities of each participant. The Illinois Agility Test (IAGT) is commonly associated with testing agility and change of direction (COD) ability (Hachana et al., 2013). The study conducted by Hachana et al. (2013) showed the IAGT to be significantly correlated to muscular leg power ($r = -0.39$, [95% CI, -0.26 to -0.44]; $p < 0.05$). Hachana et al. (2013) observed the COD IAGT to have an intraclass correlation coefficient of 0.96 and *SEM* values of 0.19 seconds. Criterion-related validity of the COD IAGT was determined by comparing the IAGT and the T-test (Hachana et al., 2013). Both tests were significantly correlated ($r = 0.31$ [95% CI, 0.24-0.39]; $p < 0.05$).

The set up for the Illinois Agility Test was simple. Eight cones were used (Hachana et al., 2013). Cones A-D were set up in a rectangle area (Hachana et al., 2013). Cones A and B were set ten yards (9.2 meters) apart (Hachana et al., 2013). Cones B and C were set eight yards (approximately 7.2 meters) apart (Hachana et al., 2013). Cones C and D were set 10 yards (9.2 meters) apart (Hachana et al., 2013). Cones one through four were set up in line ten feet (3.1 meters) apart from one another (Hachana et al., 2013). Cones one were placed in between (12 feet, 3.6 meters) cones B and C, whereas cone four will be placed in between cones A and D at the same distance (Hachana et al., 2013). A figure of the Illinois Agility Test with the instructions for running can be seen in (Appendix C).

An electrical timing system was used to record the times of the trials (Brower Timing System, Salt Lake City, UT). The Brower Timing System was used in the study conducted by Hachana et al. (2013). Mounted on two tripods were timing sensors set to begin recording time once the participant passed through the electronic sensors. The clock was stopped when the participant passed through the two electronic sensors on tripods at the finish line. The participant was asked to complete two trials with a three-minute rest period between those trials. The participants were asked to run the agility test as quickly as possible in each trial.

Countermovement Vertical Jump. There are multiple ways to perform a vertical jump. One of the most popular tests is the countermovement vertical jump (CMJ). The procedure of the CMJ test stated by Chtourou et al. (2013) begins with the participants in a standing position with legs fully extended. The participant then lowers into a squat position. Once she lowers into a proper squat, she explodes upward to reach maximal vertical height. The CMJ vertical jump was tested for reliability and factorial validity against the squat jump, Sargent jump, and the Abalakow's jump with and without arm swings (Markovic et al., 2004). The study determined the CMJ test had the highest reliability ($\alpha = 0.98$) of all the tests (Markovic et al., 2004). The factorial validity for the CMJ test was also the highest compared to the other tests, $r = 0.87$ (Markovic et al., 2004). Therefore, the countermovement vertical jump was used in this study.

The CMJ test was measured using the Vertec apparatus (Jump USA, Sunnyvale, California). The participants' vertical jump was recorded in inches. Three colored vanes are located in the Vertec. The red vanes are located 6 inches apart, whereas the white and blue vanes are 1 inch apart. The vanes are used to determine the vertical height reached by the participant.

Before any type of adjustments, the Vertec measured a 24-inch vertical jump. Before each set of CMJ trials, the participant's reach was measured. The Vertec was set to 84 inches. The participant walked through the vanes to establish the reach of her dominant hand. If the participant could not reach the vanes at 84 inches, the vanes were lowered to 72 inches to establish her reach. Once the reach was determined, the vanes were raised to 96 inches. If the vanes were previously lowered to 72 inches, the vanes were raised to 84 inches. The vanes were raised before the participants' attempted trials; this was done to limit the number of vanes the participants hit for each trial. Before each trial, the participants stood below the vanes of the Vertec. Each participant performed a CMJ. The participants were told that trials that do not count if they took a step, jumped off one foot, and/or performed a double bounce/hop jump. The participants each performed three trials with a one-minute rest period between the trials. The participants were asked to jump as high as possible for each trial.

Lower Extremity Kicking Power. The Tendo Weightlifting Analyzer (Sorinex, Slovak Republic) was used to measure the muscular power of the instep kick. A FIFA-approved size 5 ball was used for each kicking session. The participant was allowed one preparation step before striking the ball into a goal located three yards straight in front of the participant. The participant was asked to strike the ball a hard as possible with her dominant leg. The Tendo unit was attached to the shoelace of the participant's cleat. The soccer ball was placed in line with the Tendo unit. The Tendo unit analyzed the entire kicking movement and calculated the peak power and the average power in watts. The peak power was the highest power reached during the participant's kick. The average power was the average power output during the entire kicking motion. The participant had a three-minute rest period between the three kicking trials.

Stretching protocols. The static stretching protocol consisted of five stretches. The major muscle groups of the lower extremities were stretched. All of the static stretches were described by Alter (2004). The participant began the stretching her right side muscle group then switched to her left side muscle group. The participant was told to move through range of motion till she felt mild discomfort in the muscle group. The static stretching was considered short duration because the total duration will be < 90 seconds. The participants held each static stretch for 3 sets of 10-second repetitions. The total duration was 30 seconds for each muscle group. Detailed instructions for the static stretching can be seen in Appendix B.

The dynamic stretching warm-up consisted of 13 exercises. The warm-up was done in a 10-yard area. The total yardage covered by the participant during the warm-up was 180 yards. The protocol was taken from the warm-up designed by Fredrick and Szymanski (2001) with modifications made for a soccer population versus a baseball population. The complete dynamic warm-up can be seen in Appendix A. The lead researcher provided a detailed instructional period to the participants before they begin the warm-up.

Procedure

The testing location was the University of Central Oklahoma's turf football field located in Wantland Stadium on campus. There were a total of four testing dates, two days per week. Each participant participated in one week of testing depending on the participant's class schedule. The weekly testing dates had whole rest day between them. During week one, day one was a Tuesday and day two was a Thursday. Week two consisted of day one being a Monday and day two was a Wednesday. The test dates were divided into two weeks to make the completion of this research more manageable and allow for the participants' different class schedules.

Each of the participants was assigned to a test week based on their class schedule. Week one consisted of the participants performing the dynamic only stretching condition on the week's first testing day. The participants performed the combination stretching condition on the second day of the week one. Participants who were assigned to week two completed the combination stretching condition on the first day of the week and the dynamic only stretching condition on the second day of the week. The participants were asked to not partake in any individual strenuous stretching or physical activity prior to or after any of the test days.

Four assistants were trained by the lead researcher to test each muscular power test. The first assistant was responsible for instructing and measuring the jump height of all participants in the countermovement vertical jump. The instructing and timing of the Illinois agility test was the responsibility of the second assistant. Lastly, the final two assistants were to instruct and measure power of the instep kick. Two assistants worked together to record the power measurements for the instep kick. The order of the tests was randomly assigned to the participants before each session. The proper techniques for the tests were presented to the participants before the stretching condition. The lead researcher requested each participant put forth-maximal effort for each trial of each muscular power test.

The muscular power tests were performed after the stretching conditions. The lead researcher described and demonstrated each of the stretching conditions. During the demonstration, the proper technique was shown and clarification questions were allowed. Once the participants understood the stretching order and movements, they were lead through the stretching protocols. The process of the dynamic only stretching condition days began with this instruction. After the participants complete the dynamic warm-up, they reported to the first muscular test randomly assigned to them. Each participant randomly selected her testing order.

The participants were asked to perform three trials of the CMJ. A one-minute rest period was provided to the participant between each trial. After the participant completed with the CMJ trials, she was provided a rest period of at least one minute before reporting to her next muscular power test in her assigned order. Three trials were also used for the instep kick. The rest period between each trial of the instep kick was three minutes. Each participant was allowed a three-minute rest period before reporting to her next test after the instep kick. Finally, the Illinois agility test only had two trials. The participant was provided with a three-minute rest period between each trial and after all the trials were completed. Once the participants completed each test, they were asked to wait for 30 minutes until the next round of muscular testing trials. During the first 25 minutes, the participants sat and were not allowed to discuss the previous testing trials. The last five minutes of the waiting period, the participants were allowed to jog in the allotted space as a warm-up. During the five minutes, they were not allowed to statically or dynamically stretch. After 30 minutes, the participants completed another round of muscular power testing. The delayed testing procedure was the same as the acute testing procedure except for the testing order for the muscular power tests. The tests were completed in a random order during the delayed testing procedure. Following the completion of the delayed testing, the participant was done for the day.

The combination stretching condition was the designed static stretching protocol plus the dynamic only stretching protocol. The static stretching protocol was completed immediately after the dynamic stretching warm-up. The dynamic stretching protocol movements and order was reviewed before the start of testing. The static stretching protocol was shown and described to the participants by the lead researcher. Once the participants completed the combination stretching condition, testing began. Upon completion of all testing trials, the participants were asked to wait 30 minutes before the delayed testing. The instructions for 30-minute wait period after the combination stretching condition was the same as the wait period described earlier in this procedure section. Following the conclusion of the delayed testing for the combination stretching condition, the participant was done for the day.

Design and Analysis

The purpose of this study was to determine the acute and delayed effects of static stretching on muscular power output in female collegiate soccer players. The dependent variable of muscular power was tested using three tests; countermovement jump, Illinois Agility test, and instep kick through the use of the Tendo unit. The independent variable in this study was the stretching protocols, dynamic only versus the combination condition (dynamic followed by static stretching). The data used in the study were collected using a data collection sheet created by the lead researcher, which was be seen in Appendix H . Student assistants who were trained by the lead researcher collected the data. The lead researcher led each participant through all stretching conditions.

Dependent t-tests were used to determine whether significant differences in muscular power were observed between the two stretching conditions either acutely or delayed. SPSS Version 21 and Microsoft Excel were used to analyze the collected data. The null hypothesis states the dynamic only stretching condition will not produce greater muscular power compared to the combination stretching condition. To determine significance of data, an alpha level of .05 was used.

Chapter Four: Results

The objective of this study was to determine the acute and delayed effects of static stretching on muscular power in female collegiate soccer players. It was hypothesized by the lead researcher that the dynamic only condition would produce faster agility test times, higher vertical jump heights, and better measured power during the instep kick compared to the combination stretching condition both the acutely and delayed.

The highest recorded jump height for each participant was used in the statistical analysis of the countermovement vertical jump test. The fastest recorded time for each participant during the Illinois Agility Test was used in the statistical analysis. Conversely, the average of the three trials of the peak and average power recorded by the Tendo unit during the instep kick was used in the statistical analysis.

Descriptive Statistics

The descriptive statistics are reported in Table 1. There were a total of 13 individuals who participated in this study. Acutely, the participants jumped 17.77 ± 1.99 inches after the dynamic only stretching condition, whereas, the participants jumped 17.39 ± 1.70 inches after the combined stretching condition (Figure 1). In addition, the participants acutely completed the Illinois Agility Test after the dynamic only condition in 16.38 ± 0.68 seconds versus 16.47 ± 0.64 seconds after the combination stretching condition (Figure 2). The mean peak kick power immediately after the dynamic only condition and the combined condition were determined to be 2,780.46 ± 906.50 watts versus 2,875.85 ± 956.857 watts (Figure 3). Lastly, the acute mean average kick power after dynamic only stretching and the acute combination condition's mean average power were 1,972.92 ± 615.06 watts and 2,124.46 ± 783.53 watts (Figure 4).

The same measures were taken following the two stretching conditions 30 minutes after the acute testing; this is considered the delayed testing. During the delayed testing, the participants jumped 17.46 ± 2.00 inches after the dynamic condition and 17.73 ± 1.51 inches after the combined stretching condition (Figure 1). The participants finished the IAT in 16.20 ± 0.68 seconds post dynamic only stretching and in 16.37 ± 0.98 seconds post the combination condition during the delayed testing (Figure 2). Following the 30-minute wait period, the mean peak power for the dynamic condition and the combination condition were 2,574.08 ± 530.13 watts and 2,853.77 ± 771.87 watts (Figure 3). The dynamic only condition mean average power during the delayed testing was 1,865.31 ± 376.33 watts (Figure 4). After the combination condition the mean average power was 2,103.62 ± 637.93 watts (Figure 4).

Stretching Condition Comparison

Dependent t-tests were used to compare the acute and delayed effects of the two stretching conditions on each of the four variables; CMJ, IAT, kick peak power (KPP), and kick average power (KAP). As a result of the small sample size, univariate effect sizes were determined. The univariate effect size was calculated for each variable by dividing the difference of the dynamic mean and the combination mean by the standard deviation of the dynamic condition. A negative effect size means the combination condition scores were higher compared to the dynamic only condition, and vice versa for a positive effect size.

Countermovement Vertical Jump. The reach of the dominant hand for participant was taken into account for each CMJ trial. The best vertical jump minus the participant's reach was used in the statistical analysis of the data. For the CMJ acute testing, the results indicated that there was not a significant difference between the dynamic only and combination condition, $t(12) = 1.594$, $p = 0.14$ (Figure 1). While comparing CMJ delayed testing, no significant difference was observed for the two stretching conditions, $t(12) = -.746$, $p = 0.47$ (Figure 1). The acute testing's effect size for CMJ was the only positive effect size ($d = 0.19$, 2.16 % change), therefore the dynamic only condition had higher scores compared to the combination condition (Table 1). The effect size for the delayed CMJ testing was small and negative, $d = -0.13$, 1.54% lower (Table 1).

Illinois Agility Test. The fastest recorded time in the agility test for each participant was used in the statistical analysis. The results of the dependent t-tests comparing the acute IAT times after the two stretching conditions did not show a significant difference, $t(12) = 1.594$, $p = 0.54$ (Figure 2). Similarly, no significant difference was observed when comparing the stretching conditions for the IAT delayed testing, $t(12) = -1.034$, $p = 0.32$ (Figure 2). The acute ($d = -0.14$, 0.57 %) and delayed ($d = -0.25$, 1.07% testing effect sizes for IAT were both small and negative. The combination condition produced higher times compared to the dynamic only condition. Due to the inverse relationship between time and performance, the participants performed better following the dynamic only stretching condition compared to the combination stretching condition (Table 1).

Lower Extremity Kicking Power. The peak power of the instep kick was the highest power measurement recorded through the participant's entire kicking movement. The average power of the instep kick was the average power recorded through the participant's entire kicking motion. For both of these measurements of power, the mean of the three trials was used in the statistical analysis. The results of acutely completed tests showed no significant differences between dynamic only and combination for either the mean peak power ($t(12) = -.391$, $p = 0.70$) and mean average power, $t(12) = -.812$, $p = 0.43$ (Figure 3). Likewise, no significant difference was confirmed after the dependent t-test for the delayed testing for mean peak power ($t(12)$ = -

1.190, $p = 0.26$) and mean average power, t(12) = -1.282, $p = 0.22$ (Figure 3). The acute KPP ($d = -0.11$, 3.43%) and KAP (d = -0.25, 7.68%) effect sizes were both negative, meaning the combination condition had higher scores compared to the dynamic only condition for both variables. KPP and KAP had moderate effect sizes while the acute testing had small effect sizes (Table 3). Similarly to the acute testing, the delayed testing also had negative effect sizes. The effect size for delayed KPP was -0.53, 10.87% (Table 1). Lastly, the delayed KAP effect size was -0.63, 12.78% (Table 1).

Chapter Five: Discussion

Stretching is often performed during a warm up before activity to improve coordination, performance, and decrease risk of injury (Marek et al., 2005; McMillian et al., 2006; Amiri-Khorasani et al., 2010). Two common types of stretching used prior to activity are static and dynamic techniques (Amiri-Khorasani et al., 2010). Their commonality is the reason static and dynamic stretching techniques were chosen for this study. In addition, muscular power is an important aspect in high levels of sport competition, especially in soccer (Lopez-Segovia et al., 2011). Thus, the purpose of this study was to determine the acute and delayed effects of static stretching in female collegiate soccer players. It was hypothesized by the lead researcher that the participants would produce faster times in the Illinois Agility Test, higher vertical jump results, and greater power production in the instep kick after the dynamic only stretching condition compared to the combination stretching condition both acutely and delayed.

Comparing Countermovement Vertical Jump Literature

The hypothesis was not supported with any significant differences when comparing acute testing results (dynamic only versus combination) or the delayed testing results (dynamic only versus combination). Further investigation into effect sizes, showed the dynamic only condition was superior by a small amount only during the acute countermovement vertical jump testing. Chtourou et al. (2013) observed that static stretching was detrimental to countermovement vertical jump heights and dynamic stretching was beneficial. The dynamic stretching groups significantly ($p < 0.01$) increased their CMJ heights compared to the static stretching and no stretching groups in the study conducted by Chtourou et al. (2013). The opposite was observed for the delayed CMJ testing in this study. The effect size of the delayed CMJ variable showed the combination stretching condition allowed the participants to produce higher vertical jump heights (d = -.13, % change = -1.54). These results are similar to those observed in a study conducted by Donti et al. (2014).

Countermovement vertical jump increased by 4.6 ± 0.9% following long stretching protocol, which was 30 seconds of static stretching (Donti et al., 2014). In the current study, the static stretching was held for a total of 30 seconds for each muscle groups, similar to Donti et al. (2014). In a study completed by Behm et al. (2006), static stretching was held for three, 30-second intervals. The researchers observed CMJ height decreases of 5.5 to 5.7%, $p < 0.01$, which were determined to be significant changes (Behm et al., 2006). Similarly, static stretching held for 45 seconds significantly decreased CMJ heights by 5.5 ± 0.9%, $p < 0.01$, (Tsolakis & Bogdanis, 2012). Though when the static stretching was held for 15 seconds, no change was observed in CMJ heights (Donti et al., 2014; Tsolakis & Bogdanis, 2012). The differences in the effects of static stretching CMJ impairments could be determined by static stretch hold times. These differences warrant further investigation.

Comparing Change of Direction Performance Literature

Based on the effect sizes of the IAT variable both in acute and delayed testing, the hypothesis was supported. The participants produced faster time in the Illinois Agility Test after the dynamic only stretching condition compared to the combination condition in both acute testing (d = -0.14, % change = -0.57) and delayed testing (d = -0.25, % change = -1.07). These results are similar to the results found in a study carried out by Amiri-Khorasani et al. (2010). Four stretching conditions were completed by the participants in the study by Amiri-Khorasani et al. (2010); no stretching, static only, dynamic only, and combination stretching. The combination stretching was the static condition followed by the dynamic condition (Amiri-Khorasani et al., 2010). In the study, Amiri-Khorasani et al. (2010) concluded dynamic stretching was the best warm-up to prepare an individual for change of direction (COD) performance. There was a significant difference in the completion time between static stretching, 14.90 ± 0.38 seconds and dynamic stretching, 13.95 ± 0.32 seconds, as well as dynamic stretching and combined stretching, 14.50 ± 0.35 seconds (Amiri-Khorasani et al., 2010). An additional conclusion of Amiri-Khorasani et al. (2010) was that static stretching did not appear to be detrimental to change of direction performance when combined with dynamic stretching. In the current study, static stretching decreased the change of direction performance of the participants when combined with dynamic stretching.

In another study involving change of direction performance, combination of static and dynamic stretching did not adversely effect or facilitate COD performance (Wong et al., 2011). The conclusion drawn from these results was counterbalancing was occurring between the static stretching impairments and dynamic stretching facilitation (Wong et al., 2011). The stretching order was similar to the study conducted by Amiri-Khorasani et al. (2010), which was static followed by dynamic stretching.

Comparing Instep Kicking to Leg Extension Literature

No literature is available to compare the use of the Tendo unit in assessing kicking power after different stretching conditions. The use of the Tendo unit for muscular power has been compared to field assessments of muscular power (Nimz, 2011). The Tendo unit was used during an instep kick and compared to countermovement vertical jump, fly-in-40-yard dash, and the agility t-test results (Nimz et al., 2011). It was concluded that the Tendo unit was unable to be validated as an accurate assessment tool for measuring kicking power (Nimz et al., 2011). This conclusion could help explain the trouble the current researchers had in this study with the Tendo unit; these troubles will be expanded upon in the limitations section.

Though there is literature over the effects of stretching on leg extension power. Leg extension is used during an instep kick. Maximum voluntary isometric contraction (MVIC) of knee extension was tested in a study by Behm et al. (2006). Static stretching was held for three repetitions of 30 seconds, the isometric leg extension power was significantly impaired (Behm et al., 2006). Knee extension power was decreased 6.1% to 8.2 % after the static stretching compared to the participants baseline (Behm et al., 2006).

Yamaguchi et al. (2006) argued that actual sport movements are not isometric, therefore the researcher chose to measure isotonic (dynamic constant external resistance [DCER]) muscle action of leg extensors at different loads of maximum voluntary contraction (MVC; 5%, 30%, & 60%). The total time of static stretching was four repetitions of 30 seconds. Even though the type of leg contraction was different, the results were also significant lower after acute static stretching compared to non-stretching (Yamaguchi et al., 2006). At 5% of MVC participants had a 12% lower leg contraction following acute stretching compared to non-stretching (Yamaguchi et al., 2006). At 30% of MVC participants had a 6% lower leg contraction following acute static stretching compared to non-stretching (Yamaguchi et al., 2006). Lastly, at 60% of MVC, participants had a 9% lower leg contraction following acute static stretching compared to non-stretching (Yamaguchi et al., 2006). The Yamaguchi et al. (2006) study results are opposite of the trends observe in this study. The acute combination condition showed to have higher scores than the dynamic only condition. The differing results could be a result of the differing static stretching durations. The static stretches were held for a total of two minutes in the Yamaguchi et al. (2006) study versus this study, which was a total of 30 seconds. Static stretching held for at least 45 seconds or longer has been observed to be detrimental to power performance in other studies (Chtourou et al., 2013; Tsolakis & Bogdanis, 2012).

Limitations

The small sample was a limitation of this study. The goal sample size was 15 participants. Although 18 participants volunteered, five participants could not participate either due to a scheduling conflict or history of injuries. The small sample size decreases the likelihood of finding significance. Another limitation of the sample population is that only females participated in this study. Although, this is one reason this study is different from previous research, the results of this study can only be generalized to female soccer players.

The use of the Tendo Weightlifting Analyzer unit was a limitation of this study. The Tendo unit is a reliable tool for the measurement of muscular power in the vertical plane (Jennings et al., 2005). The instep kick is a multiple plane movement. During the testing, the Tendo unit had trouble computing some participants' instep kick. Even though each participant was provided the same instructions for the instep kick, the Tendo unit still had more trouble with some participants compared to others. The lack of consistent recording from the Tendo unit effected the timing of some of the participants' instep kicking. These timing issues could have affected the participants overall performance, therefore affecting the peak power and average power measurements.

The weather was also a limitation of the study. Rain or thunderstorms were considered inclement weather. The lead researcher did not account for the amount of wind that could occur during the testing times. Three of the four testing dates experienced strong wind conditions. The strong wind could have affected the participant's ability to complete the tests to their best abilities. The wind also affected the cones in the IAT. During some of the test dates, the cones moved due to wind. The researcher had to reposition the cones. The cones were measured to the specific dimensions but slight variation could have occurred due to human error.

Future Research

The researcher did not observed the results of the study to be significant but through the calculations of effect size conclusion could be drawn. The results showed that the static stretching had a positive effect on muscular power performance. The some of results are supported by previous research but others are contradicted by literature. Future studies should include the same stretching protocols but recruit a larger sample size of female soccer players. Larger sample sizes would increase the likelihood of finding significant results. One could also use the same stretching protocols with male soccer players and even different sport teams.

An area future research should be the comparison of stretching order. This study had a different stretching order (dynamic followed by static versus static followed by dynamic) compared to two previous studies (Amiri-Khorasani et al., 2010; Wong et al., 2011). If this comparison was completed in a study, better conclusions could be determined about stretching order. Not only order of stretching but amount of time static stretching should be held (total time). Literature, including the result trends of this study, is contradictory to the proper static stretching hold times for the best muscular power performance.

Further research should be conducted comparing the acute and delayed effects of stretching. Most literature is conducted over the acute effects of stretching (Behm et al., 2006; Chtourou et al., 2013; Donti et al., 2014; Tsolakis & Bogdanis, 2012; Wong et al., 2011; Yamaguchi et al., 2006), whereas the current study includes the delayed effects of stretching. A similar study set up to this one could be used but instead of the statistical analysis of the stretching condition, the statistical analyses focus on the acute and delayed effects. This future study could help determine the amount of time stretching effects muscular power. Lastly, future studies should include more muscle groups being affected in the stretching protocols. In the listed literature, the only muscle groups that were stretched were the hamstrings, quadriceps, and calves (Behm et al., 2006; Chtourou et al., 2013; Donti et al., 2014; Tsolakis & Bogdanis, 2012; Wong et al., 2011; Yamaguchi et al., 2006). The current study differs by adding more muscles to the stretching protocols such as the hip adductors and hip flexors. Research should be conducted over whether or not those additional muscle groups affect muscular power performance.

Reasons for Conflicting Literature

The literature is conflicted on the effects of static stretching on muscular power and this study adds to the disagreement. Different factors could be the cause of the inconsistencies of the literature. One factor could be the intensity of the static stretch. In multiple studies, the participant was told to hold the static stretch to the point of mild discomfort in the muscle (Chtourou et al., 2013; Donti et al., 2014; Tsolakis & Bogdanis, 2012; Yamaguchi et al., 2006; Samson et al., 2012). Discomfort or pain is subjective to the participant; therefore each participant is statically stretching at a different intensity. The subjective aspect of mild discomfort could account for the conflicting results of the literature (Chtourou et al., 2013; Donti et al., 2014; Tsolakis & Bogdanis, 2012; Yamaguchi et al., 2006; Samson et al., 2012).

Duration is also a factor in the literature. Rarely does the duration of the static stretching and rest periods match in the literature (Chtourou et al., 2013; Donti et al., 2014; Tsolakis & Bogdanis, 2012; Yamaguchi et al., 2006; Samson et al., 2012; Amiri-Khorasani et al., 2010). When the duration did match, the results were the same. Donti et al. (2014) and Tsolakis and Bogdanis (2012) both tested the effects of static stretching for one repetition of 15 seconds. Both studies observed no significant change to CMJ performance (Donti et al., 2014; Tsolakis & Bogdanis, 2012).

The differing types of participants could also factor into the opposing effects of static stretching. The current study used female collegiate soccer player, which is a specific population. No previous literature was found using the same type of participants as this study. Some research was conducted using male soccer players (Amiri-Khorasani et al., 2010; Chtourou et al., 2013). A few studies were conducted in healthy, active, male and female non-athletes (Samson et al., 2012; Wong et al., 2011; Yamaguchi et al., 2006). The only female athletes were elite gymnasts and fencers, both of which are very different sports compared to soccer and one another (Donti et al., 2013; Tsolakis & Bogdanis, 2012). According to Behm and Chaouachi (2011), trained athletes might be less susceptible to stretch induced deficits compared to untrained individuals. If true, conclusions could be difficult to make for an entire population, instead static stretching effects would have to be divided into trained versus untrained effects. Further research needs to be completed comparing static stretching effects in trained versus untrained individuals before a consistent conclusion can be made about the effects of static stretching. Also, studies completed with more female participants could also help make better conclusion about the effects of static stretching because female participants are not studied as often as male participants (Behm & Chaouachi, 2011).

Practical Application

The outcomes of this study were no significant differences were observed between dynamic only stretching and combination stretching. The trend of most of the effect sizes indicate that dynamic stretching followed by static stretching could be more beneficial for female soccer players when the objective is to produce muscular power. Therefore, the best warm-up routine for a female soccer player to complete before a competition might be a dynamic stretching protocol followed by a static stretching protocol. Though more research with larger sample sizes and direct comparison between stretching order needs to be completed before a definite conclusion can be reached.

Conclusions

Although no significance was observed from this study, the effect size shows trends of static stretching having a positive effect on muscular power this is similar to the results of the study conducted by Donti et al. (2014). These findings contradict some of the previous literature (Chtourou et al., 2013; Tsolakis & Bogdanis, 2012; Behm et al., 2006; Yamaguchi et al., 2006). In order to draw better conclusions about the effects of static stretching on muscular power in female soccer players, further research needs to be completed with this study's stretching protocols in a larger sample size.

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Table 1

Descriptive Statistics and Effect Sizes for Testing Conditions

Variables	M	SD	Minimum	Maximum	*d*	% Change
Acute						
CMJ					0.19	2.16
Dynamic (in.)	17.77	1.99	14.0	22.0		
Combination (in.)	17.39	1.70	15.0	22.0		
IAT					-0.14	-0.57
Dynamic (sec.)	16.38	0.68	15.05	17.67		
Combination (sec.)	16.47	0.64	15.27	17.60		
KPP					-0.11	-3.43
Dynamic (W)	2780.46	906.50	1542	4425		
Combination (W)	2875.85	956.86	1608	4397		
KAP					-0.25	-7.68
Dynamic (W)	1972.92	615.06	1108	3283		
Combination (W)	2124.46	783.53	913	3436		
Delayed						
CMJ					-0.13	-1.54
Dynamic (in.)	17.46	2.00	14.5	21.5		
Combination (in.)	17.73	15.1	15.5	20.0		
IAT					-0.25	-1.07
Dynamic (sec.)	16.20	0.68	15.40	17.5		
Combination (sec.)	16.37	0.98	15.15	19.00		
KPP					-0.53	-10.87
Dynamic (W)	2574.08	530.13	1776	3424		
Combination (W)	2853.77	771.87	1743	4168		
KAP					-0.63	-12.78
Dynamic (W)	1865.31	376.34	1355	2570		
Combination (W)	2103.62	637.93	1166	3106		

Note. CMJDA = Countermovement Jump Dynamic Acute, CMJCA = Countermovement Jump Combination Acute, IATDA = Illinois Agility Test Dynamic Acute, IATCA = Illinois Agility Test Combination Acute, KPPDA = Kick Peak Power Dynamic Acute, KPPCA = Kick Peak Power Combination Acute, KAPDA = Kick Average Power Dynamic Acute, KAPCA = Kick Average Power Combination Acute, *d* = Univariate effect size.

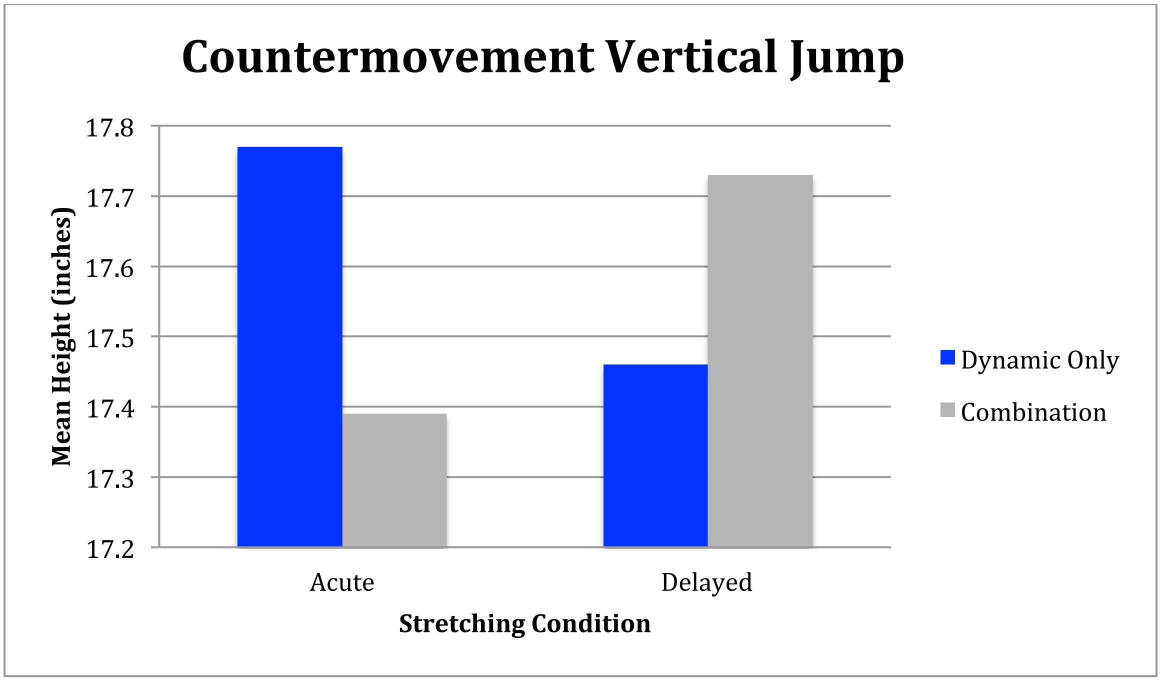


Figure 1. A bar graph of the differences in CMJ heights between stretching conditions following acute and delayed testing. The mean CMJ height was 17.77 ± 1.99 inches after the dynamic only condition during the acute testing, while CMJ height was 17.39 ± 1.70 inches after the combination condition. The delayed testing results showed the CMJ height was 17.46 ± 2.00 inches after the dynamic only versus 17.73 ± 1.51 inches following the combination condition.

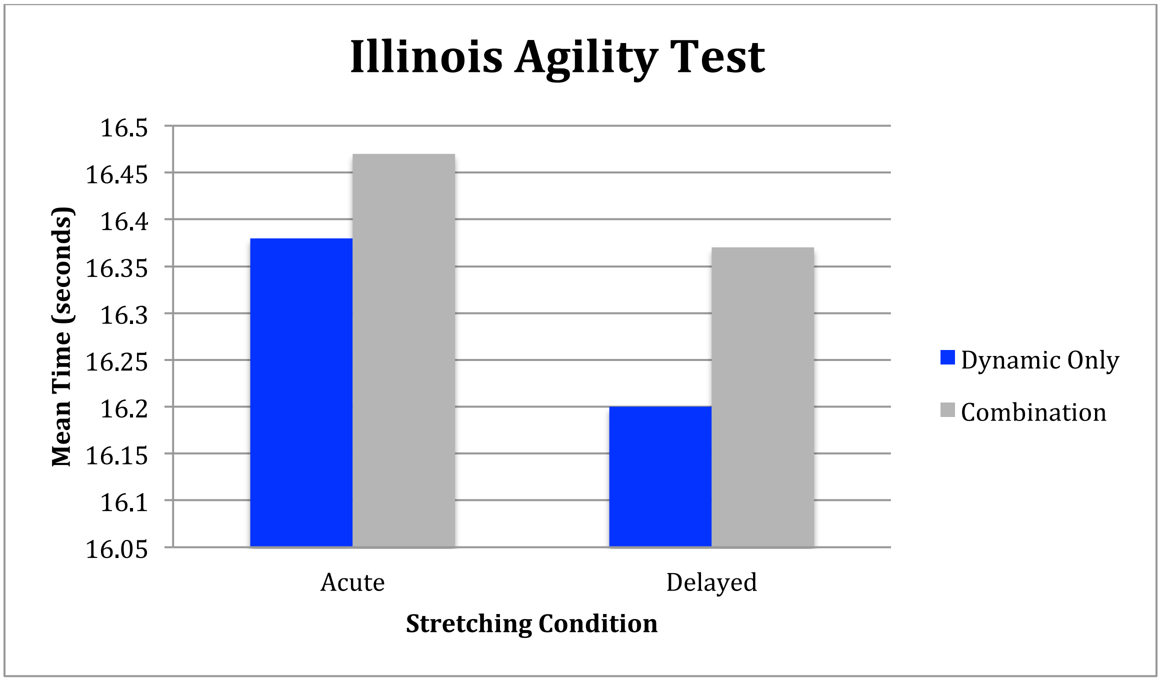


Figure 2. A bar graph of the differences in IAT times between stretching conditions following acute and delayed testing. The participants finished the IAT in 16.38 ± 0.68 seconds after the dynamic only condition versus 16.47 ± 0.64 seconds during the acute testing. In the delayed testing, the participants finished the IAT in 16.20 ± 0.68 seconds (dynamic only) and 16.37 ± 0.98 seconds (combination condition).

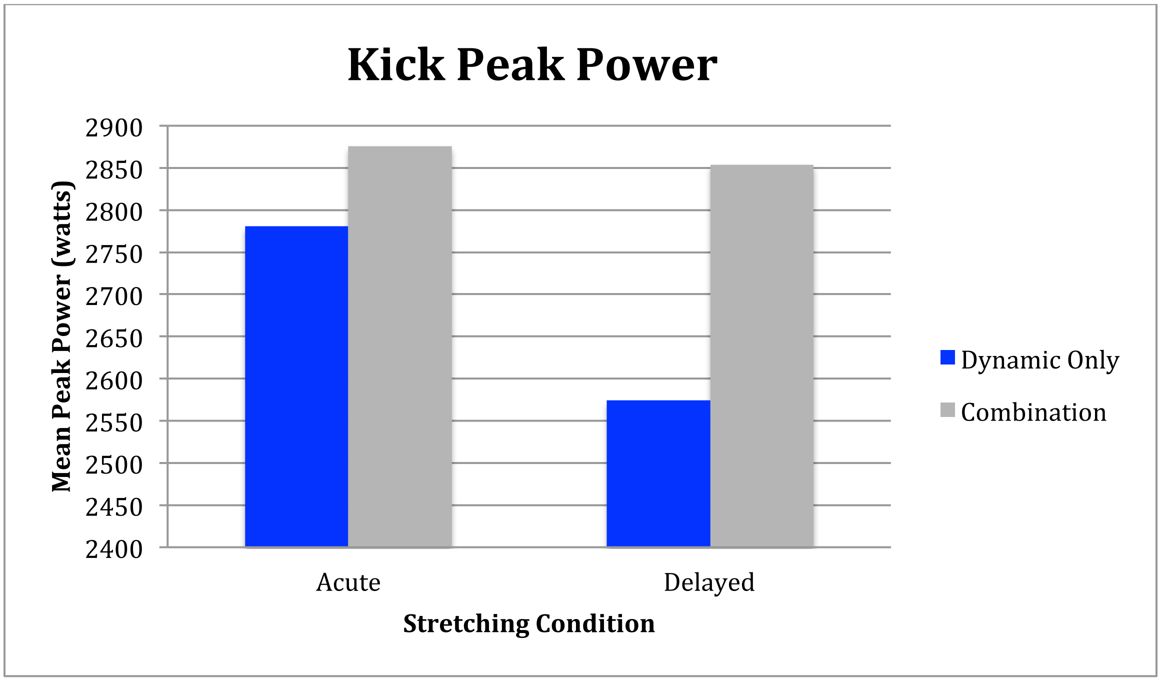


Figure 3. A bar graph of the differences of kick peak power between stretching conditions following acute and delayed testing. The acute testing results for peak power were 2780.46 ± 906.50 watts after dynamic only stretching and 2875.85 ± 956.86 watts after combination stretching. Similarly, the peak power during the delayed testing was 2574.08 ± 530.13 watts (dynamic only) and 2853.77 ± 771.87 watts (combination condition).

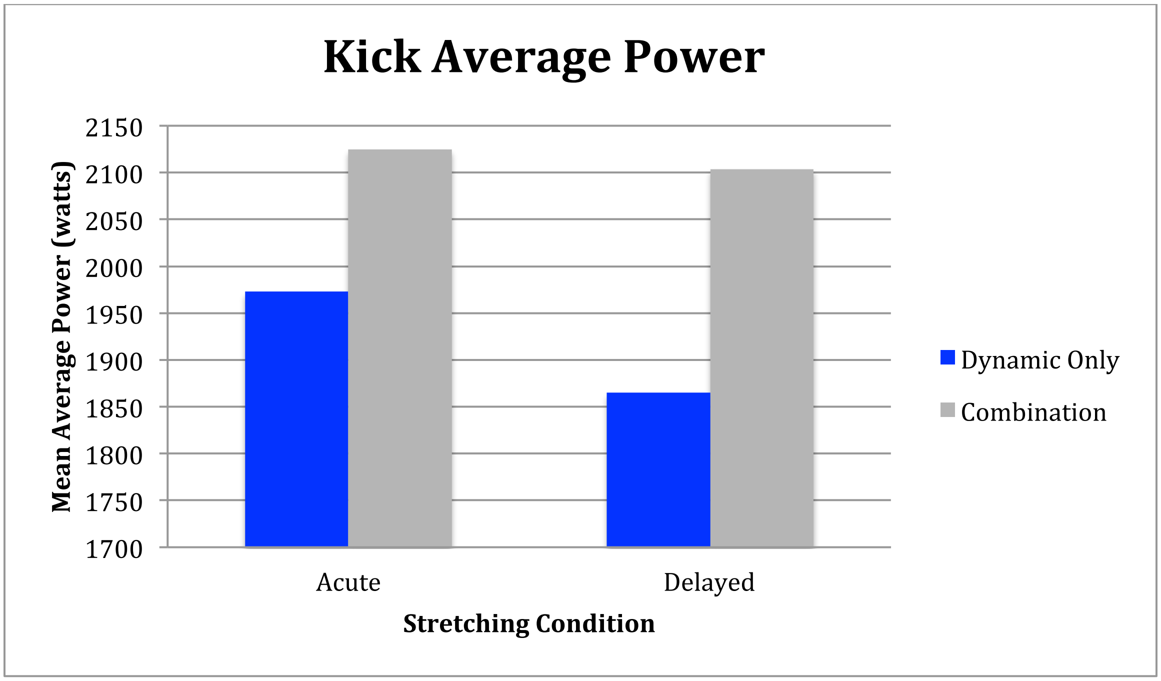


Figure 4. A bar graph of the differences of kick average power between stretching conditions following acute and delayed testing. The acute testing results for average power were 1972.92 ± 615.06 watts after dynamic only stretching and 2124.46 ± 783.53 watts after combination stretching. The average power during the delayed testing was 1865.31 ± 376.34 watts after dynamic only stretching and 2103.62 ± 637.93 watts following the combination stretching condition.

Appendix A

Dynamic Stretching Protocol

Dynamic Warm-up

The warm-up area will be 10 yards in length.

1. Jog while performing arm hugs. (F/B)
2. Skips with arm circles (F/B)
3. Side slide while performing arm hugs (L)- switch the way participant is facing at 5 yards
4. Quad Pull: Athlete will be standing with good straight posture. She will drive knee to 90-degree angle at the hip, then grab leg just above the ankle and pull ankle behind her. (F)
5. Leg Cradle: Grab leg just above the ankle and pull foot into the body. The hip will flex and rotate laterally. Once the foot is pulled into body and hip is laterally rotated, she will push her thigh toward the ground. The position will be held for 3 seconds then athlete will take step and continue to opposite leg. (F)
6. Walking lunge: sprint style, (F/B)- make sure to bring opposite arm to opposite leg, elbows will need to maintain 90 degree angle, bring hand to the face cheek
7. Hand Walk (Inch Worm): (F)- Go to 5 yards then walk the remain 5 yards
8. Forward lunge with forearm to instep: athlete will use opposite arm to stabilize while touching the same side forearm to the ground. Elbow should be in the instep of flexed leg. (F)
9. Dog & Bush (Hurdle Step Over): walking, at 5 yards switch from F to B
10. Lateral Lunge: switch the direction the participant is facing at 5 yards
11. A-Skips: (F/B/L)- hand to face cheek every time, knee up/heel up/ toe up
12. Heel-Ups for 5 yards then she takes 3 explosives running steps within the remaining 5 yards
13. High knees: for 5 yards then she takes 3 explosives running steps within the remaining 5 yards

Overall, the athlete will be travel 180 yards in the dynamic warm-up.
F= Forward
B= Backwards
L= Lateral

Common Cues:

- Knee up/heel up/toe up
- Heel tight to hamstring
- Eyes straight ahead
- Alignment of heads, shoulders, hips, knees, and ankles
- Make sure to have hips underneath upper body
- Knee in-line with ankle, weight on front heel and back ball of foot

The protocol was taken from the warm-up designed by Fredrick and Szymanski (2001) with modifications made for a soccer population versus a baseball population.

Appendix B

Static Stretching Protocol

Static Stretching Protocol

- **Gastrocnemius stretch:**
  1. Stand upright 1 meter from the wall.
  2. Bend one leg forward and keep the opposite leg straight.
  3. Lean against the wall without losing the straight line of your head, neck, spine, pelvis, rear leg, and ankle.
  4. Keep the heel of rear foot down, sole flat on the floor, and foot pointing straight forward.
  5. Exhale, and flex your forward knee toward the wall.
  6. Hold the stretch for 3 sets of 10 seconds.

- **Hamstrings stretch:**
  1. Sit upright on the floor with both legs straight.
  2. Flex one knee and slide the heel until it touches the inner side of the opposite thigh.
  3. Lower the outer side of the thigh and calf of the bent leg onto the floor.
  4. Exhale, and while keeping the extended leg straight, bend at the hip and lower your extended upper torso from the hips onto the extended thigh. Try to grab toes with opposite hand but must maintain straight back.
  5. Hold the stretch for 3 sets of 10 seconds.

- **Quadriceps stretch**:
  1. Side lying
  2. Flex one knee and raise your heel to your buttocks.
  3. Exhale, reach behind, and grasp your raised foot with one hand. Grab above the ankle. Must have ankle in a dorsiflexed position.
  4. Inhale, and pull your heel toward your buttocks without over compressing the knee.
  5. Hold the stretch for 3 sets of 10 seconds.

- **Adductors stretch:**
  1. Sit upright on the floor with your legs flexed and straddled, and heels touching each other.
  2. Grasp your feet or ankles and pull them as close to your groin as possible. Maintain straight back.
  3. Hold the stretch for 3 sets of 10 seconds.

- **Hip flexors stretch:**
  1. Stand upright with the legs straddled (spread sideways) about 60 cm (2 ft.) apart.
  2. Flex one knee, lower your body, and place the opposite knee on the floor.
  3. Roll back foot under so that the top of the instep rests on the floor.
  4. Bring same elbow into flexed leg’s instep.
  5. Exhale, and slowly push the front of the hip of the back leg toward the floor.
  6. Hold the stretch for 3 sets of 10 seconds.

Appendix C

Student Assistant Instructions

Student Assistant Instructions

Countermovement Vertical Jump Instructions

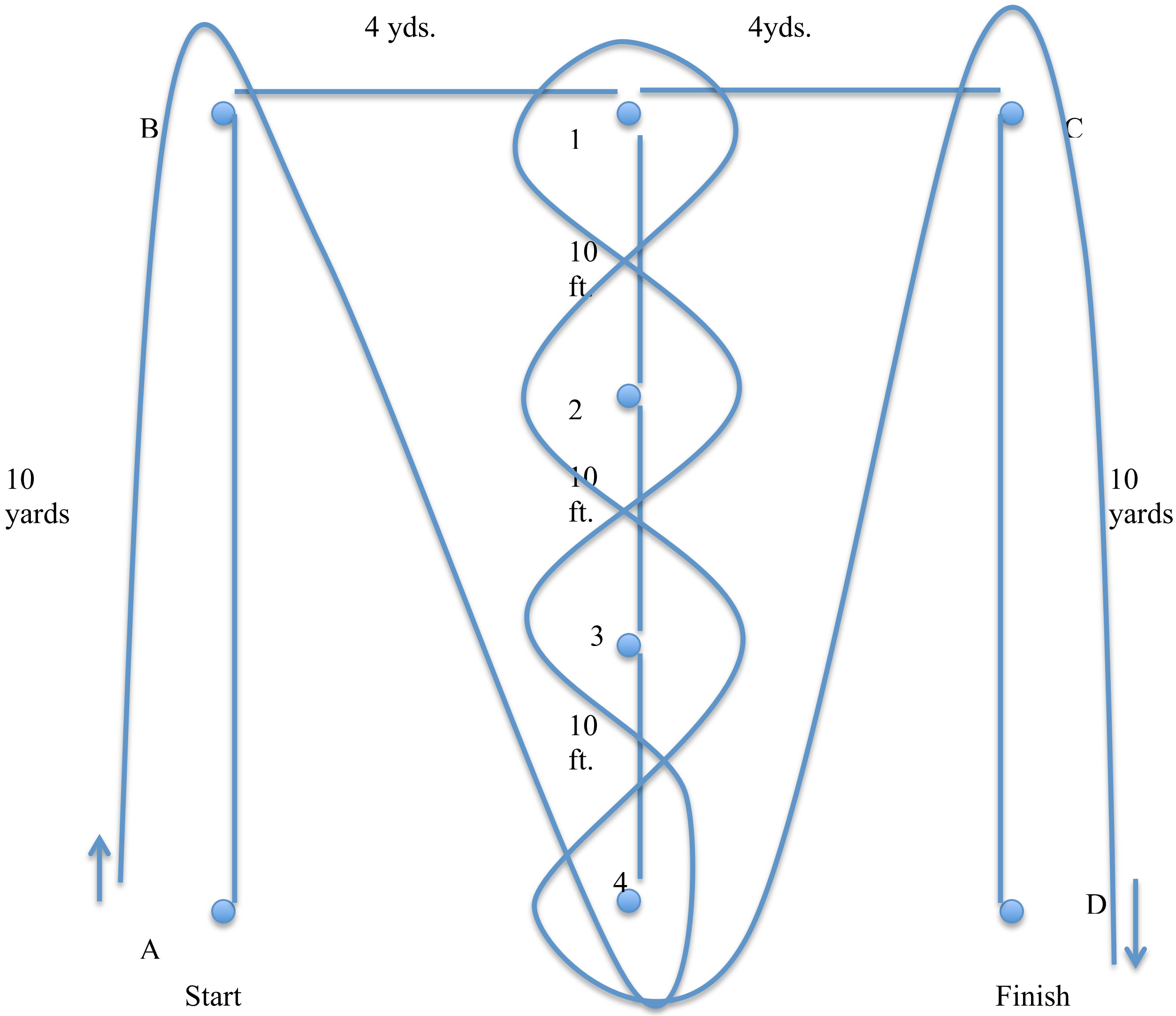
1. Set Vertec to 84 inches
2. Participant walks through the vanes to establish reach of dominant hand
3. Record the reach of participant
4. Set Vertec to 96 inches
5. Participant stands under the vanes
6. Participant must jump off two feet. Instruct them: both feet on ground, dip/squat, and jump as high as they can and touch the vanes. The trial does not count if they take a step, bounce/hop, or double hop.
7. Measure jump and record jump
8. Participant has 3 trials, 1-minute rest in between the trials.

Illinois Agility Test

1. Set up cones in the correct manner (Next Page).
2. Participant starts in a runner's start on both feet.
3. Once the participant passes through the starting line, the time will begin recording.
4. Participant runs as fast as they can through the agility test
5. Once the participant crosses the finish line, the time stops recording.
6. Participant has 2 trials, 3-minute rest in between the trials.

Instep Kicking Power

1. Input weight of participant (in kilos) into the Tendo unit.
2. Attach the Tendo unit to the shoelace of the participant's dominant foot.
3. Place soccer ball in line with the Tendo unit.
4. Allow the participant to determine the distance of her one step.
5. Ask participant to get into position that allows her to take her one step before kicking the soccer ball.
6. Reset the Tendo unit, the power reading should be a zero.
7. Have the participant kick the ball as hard as she can into the net.
8. Record the average power and peak power
9. Participant has 3 trials, 3 minute rest in between trials



Curved line is path taken by participant.

Straight lines are distances between the cones.

Appendix D

Written Permission from Head Coach

I grant Megan Bolin permission to invite the University of Central Oklahoma women's soccer team to participate in her Graduate Thesis research study.

Head Coach Print: MIKE COOK

Head Coach Signature: ____________________

Date: 11/18/15

Appendix E

IRB Application Approval

Melissa Powers

From: IRB
Sent: Tuesday, November 24, 2015 10:19 AM
To: mbolin7@uco.edu; Jill Robinson; Melissa Powers
Subject: IRB #15191 Approval
Attachments: Approved-stamped ICF.pdf

November 24, 2015 IRB Application #: 15191

Proposal Title: Effects Of Static Stretching On Muscular Power In Female Collegiate Soccer Players

Type of Review: Initial-Expedited

Investigator(s):

Ms. Megan Bolin
Ms. Jill Robinson
Dr. Melissa Powers
Department of Kinesiology & Health Studies
College of Education & Professional Studies
Campus Box 189
University of Central Oklahoma
Edmond, OK 73034

Dear Ms. Bolin, Ms. Robinson and Dr. Powers:

Re: Application for IRB Review of Research Involving Human Subjects

We have received your materials for your application. The UCO IRB has determined that the above named application is APPROVED BY EXPEDITED REVIEW. The Board has provided expedited review under 45 CFR 46.110, for research involving no more that minimal risk and research category 7.

Date of Approval: 11/24/2015
Date of Approval Expiration: 11/23/2016

If applicable, informed consent (and HIPAA authorization) must be obtained from subjects or their legally authorized representatives and documented prior to research involvement. A stamped, approved copy of the informed consent form will be sent to you via campus mail. The IRB-approved consent form and process must be used. While this project is approved for the period noted above, any modification to the procedures and/or consent form must be approved prior to incorporation into the study. A written request is needed to initiate the amendment process. You will be contacted in writing prior to the approval expiration to determine if a continuing review is needed, which must be obtained before the anniversary date. Notification of the completion of the project must be sent to the IRB office in writing and all records must be retained and available for audit for at least 3 years after the research has ended.

It is the responsibility of the investigators to promptly report to the IRB any serious or unexpected adverse events or unanticipated problems that may be a risk to the subjects.

On behalf of the UCO IRB, I wish you the best of luck with your research project. If our office can be of any further assistance, please do not hesitate to contact us.

Sincerely,

Robert D. Mather, Ph.D.
Chair, Institutional Review Board
NUC 341, Campus Box 132
University of Central Oklahoma
Edmond, OK 73034
405-974-5479
irb@uco.edu

Appendix F

Informed Consent Form

University of Central Oklahoma
Informed Consent Form

Research Project Title: Effects of Static Stretching on Muscular Power in Female Collegiate Soccer Players.

Researchers: PI- Megan Bolin, Co-PI- Ms. Jill Robinson, Co-PI- Dr. Melissa Powers

Purpose of this Research: To determine the acute and delayed effects of static stretching on muscular power performance in female collegiate soccer players.

Procedures Involved: You will be asked to complete three muscular power test procedures after a stretching protocol. The two stretching protocols are either a dynamic only stretching protocol or a combination stretching protocol. The dynamic stretching protocol will include multiple stretches that focus on warming up the total body with an emphasis on the lower body. The 13 movements will be done in a 10-yard area. The stretches begin as single directional movements progressing to multi-directional movements. The combination stretching protocol will be the dynamic protocol followed by static stretching movements. There are six lower body static stretches that you will be instructed to perform. The three muscular power tests include the countermovement vertical jump, Illinois Agility Test, and instep-kick power. During the countermovement vertical jump, you will be asked to jump as highest as possible to touch a vane on the Vertec apparatus. You will be then be asked to complete the Illinois Agility test as quickly as possible. The Illinois Agility Test includes forward running with changes of direction. Lastly, the instep kick power test will require you to kick the ball as hard as possible at a target. You will complete these testing procedures twice on each test day.

Expected length of participation: You will take part in two test days for one week. The stretching and testing procedures will take approximately 1.5 to 2 hours per test day. Total of 3 to 4 hours of participation.

Potential Benefits: You could learn specific movement patterns in regards to stretching that may be helpful in their future physical activities.

Potential Risks or Discomforts: The risks of this study are minimal. The muscular power tests include movements that are similar to those used in daily training routines in soccer.

Contact Information for Researchers:
Megan Bolin, Email address: mbolin7@uco.edu, Phone number: (405) 205-4686.
Ms. Jill Robinson, Email address: jrobinson@uco.edu.

Dr. Melissa Powers, Email address: mpowers3@uco.edu

Contact Information for UCO IRB: UCO-IRB Office, (405) 974-5497

Explanation of Confidentiality and Privacy: We will maintain all information regarding your participation confidential. Only the research team will have access to the study results. These results will be kept in a locked office or a password protected computer.

Assurance of Voluntary Participation: Your participation in this study is completely voluntary. You are not required to participate. Your participation will not impact, positively or negatively, your relationship with UCO, the researchers, or your team. You may also withdraw from this study at any time with no penalty to you.

AFFIRMATION BY RESEARCH SUBJECT

I hereby voluntarily agree to participate in the above listed research project and further understand the above listed explanations and descriptions of the research project. I also understand that there is no penalty for refusal to participate, and that I am free to withdraw my consent and participation in this project at any time without penalty. I acknowledge that I am at least 18 years old. I have read and fully understand this Informed Consent Form. I sign it freely and voluntarily. I acknowledge that a copy of this Informed Consent Form has been given to me to keep.

Research Subject's Name: ______________________________

Signature: ______________________________

Date: ______________________________

APPROVED
NOV 24 2015
UCO IRB

APPROVAL
NOV 23 2016
EXPIRES

Appendix G

Participant Injury History Questionnaire

Participant Injury History Questionnaire

Please answer questions honestly and to the best of your knowledge.

	YES	NO
1. Have you had any lower body surgeries in the past 12 months?		
2. Have you had any fractures to your lower body in the past 12 months?		
3. Have you sustained any lower body injuries that have caused you to sit out of soccer-related activities in the past 3 months?		

If answered “yes” to any of the above questions, please explain below:

____

____

____

____

____

Appendix H

Data Collection Sheet

Code Number: _______
Weight in kilograms: _______
Testing Order: ____________

Dynamic Only Stretching: Acute

Countermovement Vertical Jump: recorded in inches

Reach	Trial 1	Trial 2	Trial 3

Illinois Agility Test: recorded in seconds

Trial 1	Trial 2

Instep Kicking Power: recorded in watts

	Trial 1	Trial 2	Trial 3
Peak Power			
Average Power			

Code Number: _______
Weight in kilograms: _______
Testing Order: ____________

Dynamic Only Stretching: Delayed

Countermovement Vertical Jump: Recorded in inches

Reach	Trial 1	Trial 2	Trial 3

Illinois Agility Test: recorded in seconds

Trial 1	Trial 2

Instep Kicking Power: recorded in watts

	Trial 1	Trial 2	Trial 3
Peak Power			
Average Power			

Code Number: _______
Weight in kilograms: _______
Testing Order: ____________

Combination Stretching: Acute

Countermovement Vertical Jump: Recorded in inches

Reach	Trial 1	Trial 2	Trial 3

Illinois Agility Test: recorded in seconds

Trial 1	Trial 2

Instep Kicking Power: recorded in watts

	Trial 1	Trial 2	Trial 3
Peak Power			
Average Power			

Code Number: _______
Weight in kilograms: _______
Testing Order: ____________

Combination Stretching: Delayed

Countermovement Vertical Jump: Recorded in inches

Reach	Trial 1	Trial 2	Trial 3

Illinois Agility Test: recorded in seconds

Trial 1	Trial 2

Instep Kicking Power: recorded in watts

	Trial 1	Trial 2	Trial 3
Peak Power			
Average Power			