THE EFFECTS OF A MINI-BAND WARM-UP, A MEDICINE BALL WARM-UP AND
STATIC STRETCHING ON LOWER BODY POWER

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THE EFFECTS OF A MINI-BAND WARM-UP, A MEDICINE BALL WARM-UP AND STATIC STRETCHING ON LOWER BODY POWER

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MASTER OF SCIENCE

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ABSTRACT

The purpose of this study was to investigate the effects of four different warm-up conditions on vertical jump performance. The warm-ups included a static stretching routine, dynamic medicine ball routine, mini-band routine, and a 5-minute jog, which was the control. The subjects were 23 NCAA Division 1 women’s soccer players from North Dakota State University who performed three vertical jumps on an Advanced Medical Technology Inc. (AMTI) Force Plate after each of the four warm-up routines. The subjects were randomized into four groups for the study and rotated between the four warm-up routines, completing one routine each day in a random order. The results of the one-way repeated measures analysis of variance showed statistical significance (F=7.87, p=.007). Follow-up pairwise comparisons were done; the only statistically significant result was between the static stretching condition and the control/jog (t=-5.15, p<0.001).
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Lastly, I would like to thank Adam Hermann, my current supervisor for his constant support and understanding in helping me to achieve my goal of finishing my thesis.
DEDICATION

I would like to take this time to dedicate my Master of Science Thesis project to my family. Without the continued support and inspiration from my parents, Robert and Jean Lopez, and sister, Jennifer Lopez, I would not have been able to successfully complete this program and project. I am extremely grateful for them standing behind me during this journey. I would also like to dedicate this project to Jason Miller, NDSU Director of Athletic Performance- Olympic Sports, and Gene Taylor, former NDSU Director of Athletics for providing me with an opportunity to achieve the goal of obtaining my Master’s through a Graduate Assistantship of Strength and Conditioning. This opportunity afforded me the ability to do a job that I love, while furthering my education, all while sparing me the financial burden of having to pay for school. I will be forever indebted to the kindness of Jason, Gene, and NDSU.
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CHAPTER I. INTRODUCTION

It is a common practice to perform a warm-up before activity because it has been shown to improve performance as well as possibly decrease the risk of injury. (Hough, Ross, & Howatson, 2009). The purpose of an active warm-up is to help the athletes increase performance by raising the core temperature of their body (Bishop, 2003). Increased heart and metabolic rates help to improve transportation of oxygen and fuel to the muscle tissues. In addition, warm-ups increase rates of glycolysis and high energy phosphate degradation, moreover, help the rate of nerve conduction which help the rate of obtaining muscle contraction (Brown, Hughes, & Tong, 2008; Febbraio, Carey, Snow, Stathis, & Hargreaves, 1996; Bishop, 2003; Fletcher, 2010). There are two most commonly known and debated forms of warm-ups.

The first, and most commonly identified form of warming the body up, is known as static stretching. This form of stretching was often believed to aid in performance increases and injury decreases. Static stretching, has been used for decades, but has recently been a hot topic of discussion of whether it is as truly effective as once claimed. Static stretching has been found to be effective in causing an acute increase in the range of motion (ROM) at a joint (Young & Behm, 2002). However, it has been found that static stretching can produce a significant acute decrement, of approximately 5-30% in strength and power production of the stretched muscle groups (Young & Behm, 2002; Cornwell, Nelson, & Sidaway, 2002). On the contrary, new research has shown that injury prevention is doubtful; while the components of strength, power, speed, and jump performance are being negatively impacted, or decreasing (Fletcher, 2010).

A second warm-up that has been frequently used in recent years is termed dynamic or active stretching or movement. Dynamic stretching is defined as controlled movements through the active joint range of motion for each joint (Fletcher & Jones, 2004). Dynamic or active
movements include exercise and are prone to induce a greater metabolic and cardiovascular change (Bishop, 2003). Performing dynamic stretches in a warm-up has been shown to result in an increase in performance (Fletcher, 2010). Researchers have compared and contrasted the results of static and dynamic stretching or movement patterns and positive performance increases have been associated with utilizing these components in a warm-up (Holt & Lambourne, 2008). When compared to static movements, dynamic stretching out-performs its static counterpart in high intensity, short duration, performance, and muscular function tests (Faigenbaum, Bellucci, Bernieri, Bakker, & Hoorens, 2005).

The vertical jump test is a common and valid measure of power output (Church, Wiggins, Moode, & Crist, 2001). This action embodies a ballistic movement that captures maximal explosive power (Bosco, Luhtanen, & Komi, 1983). The vertical jump has many derivations that enable information to be gathered about various neuromuscular and performance qualities of an individual (Cronin, Hing, & McNair, 2004). Vertical jump is generally measured by the use of a Force Plate, Jump Mat, or Vertec.

**Purpose**

The purpose of this study was to determine the effect of a mini-band warm-up, a medicine ball warm-up, and static stretching on lower body power.

**Research Questions**

1. Does static stretching prior to vertical jumping effect performance?
2. Does a dynamic medicine ball warm-up prior to vertical jumping effect performance?
3. Does a dynamic mini-band warm-up prior to vertical jumping effect performance?
Research Hypotheses

1. It was hypothesized that the static stretching warm-up will result in a decrease in performance in the vertical jump.

2. It was hypothesized that the dynamic medicine ball warm-up will result in a performance increase in the vertical jump.

3. It was also hypothesized that the dynamic mini-band warm-up will result in a performance increase in the vertical jump.

Significance of Study

This study was significant because it aimed to identify the effects of individual components of a dynamic warm-up on performance. Athletes currently use a variety of warm-ups, some based on research results, some just based on tradition. This study was also significant because there has been little published research examining the effects of different types of medicine ball and mini-band dynamic warm-ups.

Assumptions

1. Verbal cues for stretching created the same level of tension of the stretch for each participant.

2. Verbal cues for the two dynamic warm-ups created the same effect for each participant.

Limitations

1. Not a true counterbalanced design of warm-up and tests.

2. Some familiarization of the drills may take place.

3. Only testing female soccer players.

Delimitations

1. Participants were all Division I athletes
2. Participants with a history of knee injuries were excluded from the study.
3. Testing was done over the course of two weeks to limit the effects of off-season training adaptation for their sport.

**Organization of Thesis**

Chapter I: Introduction- Chapter I provides an overview on the effects of a mini-band warm-up, a medicine ball warm-up and static stretching on lower body power.

Chapter II: Review of Literature- Chapter II is a review of the literature of different types of warm-ups and the effects on performance.

Chapter III: Methodology- Chapter III provides detailed information on the methods that were be used in studying the effects of different warm-up protocols on performance.

Chapter IV: Manuscript- Chapter IV includes the results of the study that will be submitted for publication.

Chapter V: Summary and Conclusions- Chapter V will be a summary and conclusions about the different types of warm-ups and the effects on performance based on the results of this study.

**Definitions**

Static stretching—Involves moving a limb to the end of its range of motion (ROM) and holding the stretched position for 15–60 s (Behm & Chaouachi 2011).

Dynamic warm up—Involves exercise and is likely to induce greater metabolic and cardiovascular changes than static stretching (Bishop, 2003).

Dynamic stretching—Stretching that involves controlled movement through the active range of motion for a joint (Fletcher, 2010).
Medicine ball warm up—Exercises performed while holding and throwing a medicine ball.

Mini-band warm up—Exercises performed with Perform Better mini-bands around the knee, ankle, or foot.

Healthy—A person who does not suffer from any health related illness.

Knee injuries—Those who have had or have a sprain or tear to one of the ligaments of the knee.

Lower body power output tests—Tests that measure power, such as vertical jump.

Vertical Jump—The vertical jump test is performed with a counter movement using one’s arms, where there is bending of the knees immediately prior to the jump.
CHAPTER II. LITERATURE REVIEW

This literature review discusses the findings from previous research on the effects of static stretching, dynamic warm-ups, and the effect they have on the performance on lower body power output, such as the vertical jump. The purpose of this study was to determine the effect of a mini-band warm-up, a medicine ball warm-up, and static stretching on lower body power.

Overview of Static Stretching and Dynamic Warm-ups

Warming up prior to engaging in physical activity has become an essential component to an athletes’ increased rate of performance in addition to decreasing the risk of injury (Hough, Ross, & Howatson, 2009). This process is done through the use of active warm-ups to help increase the athletes’ performance and raise their core temperature of their body (Bishop, 2003). Research has shown that an elevated heart rate, in addition to metabolic rate can help to improve the transportation of oxygen and fuel to the muscle tissues, which could potentially increase performance.

There are two commonly known and often debated forms of warm-ups. The first, and most commonly identified form of warming the body up, is known as static stretching. The second warm-up that has become a more frequently used form of warming up is identified as dynamic or active stretching or movement. Both methods of warming up have been used in various settings and fields, however, research is needed in identifying which form of warming up best provides an individuals’ body with the best situation to achieve success.

Static stretching, dynamic stretching or movement, and the correlation between the warm-ups, vertical jump and power output are discussed in this review of literature.
Static Stretching

Static stretching is one of the most commonly used methods for increasing flexibility and range of motion (ROM) in individuals. It is believed that static stretching is effective in improving performance (Knudson, Bennett, Corn, Leick, & Smith, 2001). The purpose of static stretching during the warm-up phase is to improve flexibility and range of motion. Static stretching may allow for maximal force production, increase in performance in the activities the athletes will engage in following the warm-up, and to reduce the possibility of acquiring an injury (Robbins & Scheuermann, 2008).

As defined by Young and Behm (2002), static stretching involves moving a limb into a near maximal position and holding that position for the duration of 15 to 60 seconds. The important components of static stretching are to perform the movements at less than 75 percent of maximum velocity and through the same plane of motion, through the same range of motion, and at the same joint angles used when performing skills in a specific activity (Alter, 1996). This principle was originally put forward by Wallis and Logan in 1964 (Silveira, Sayers, & Waddington, 2011). There has been much research supporting the effects of static stretching. A reduction in the risk of injury, a decrease in muscle inflexibility, easing of pain, and improved athletic performance are significant factors in performing static stretching movements (Robbins & Scheuerermann, 2008; Smith, 1994; Worrell, Smith, & Windegardner, 1994).

Although static stretching was thought to benefit performance in the past, continued research over the last few years has resulted in a controversial debate as to whether static stretching prior to physical activity positively effects or inhibits performance (Bishop, 2003; Behm & Chaouachi, 2011). Current studies have indicated that static stretching may actually have a negative effect on power output, force, balance, and maximum vertical jump height.
(Schilling & Stone, 2000; Burkett, Phillip, & Ziuraitis, 2005). “Research indicates, that static stretching can produce a significant acute decrement, of approximately 5-30%, in strength and power production of the stretched muscle groups” (Young & Behm, 2002, p. 34). Strength (Bacurau et al., 2009; Costa et al., 2009; Herda et al., 2008; Morse et al., 2008), power (Manoel et al., 2008; Samuel et al., 2008), speed (Fletcher & Anness, 2007; Fletcher & Jones, 2004; Nelson et al., 2005; Sayers et al., 2008), and jump performance (Holt & Lambourne, 2008; Pearce et al., 2009) may be negatively affected when using static stretching prior to a physical activity (Fletcher, 2010; Shier, 1999; Thacker et al., 2004).

Additionally, evidence has also suggested that static stretching may not aid in the prevention of injuries (Fletcher, 2010; Shier, 1999). In a study conducted by Young and Behm (2003), researchers made an effort to identify the effect of submaximal running, static stretching, and practice jumps on explosive force production and jumping performance. The study included 16 participants, 13 male and 3 female volunteers that participated in five different warm-ups in a randomized order prior to performing two jump tests. The five warm-ups included: control, 4-minute run, static stretch, run and stretch, run, stretch, and practice jumps. The subjects were given 2 minutes rest between the various warm-up and jump test conditions. The jump tests that were studied were the drop jump and a concentric jump. The concentric jump:

…involved jumping with a 10kg bar on the shoulders performed on a modified Smith machine. Subjects were required to hold a static squat position at a 100 degree knee angle, measured by a manual goniometer for a 2 second period, and then jump for maximum height while extending the legs as fast as possible (Young & Behm, 2003, p. 23).
A Kistler force platform (Z4852/C) operating at 1000 Hz measured the force generated by the participant during the push off phase of the jump (Young & Behm, 2003). For the drop jump test, participants placed their hands on their hips and stepped off a 0.30m tall box “with a straight leg to ensure the fall commenced from a 30 cm height” (Young & Behm, 2003, p. 23). Once the subjects made contact with the ground, they were instructed to jump for a maximum height, with the intent of having as minimal ground contact time as possible. The jump height and the contact times were measured using a Swift Performance Equipment, contact mat system. In addition to the data collected from the jumps, Electromyographic (EMG) was also recorded using surface electrodes (Young & Behm, 2003). Results showed that vertical jump height was significantly better after a running warm-up, than using a control warm-up, and running plus 4 minutes of stretching resulted in significantly worse performance than just the running warm-up. This study also supports evidence that as little as 2 minutes of static stretching can negatively decrease power performance (Young & Behm, 2002).

However, there are also several, research studies that have found no effect on lower body power output tests, such as the vertical jump. In a study conducted by Knudson, Bennett, Corn, Leick, & Smith (2001), researchers studied 20 young adult volunteers, 10 male and 10 female. The subject sample “was selected to be as heterogeneous as possible ranging from intercollegiate athletes to moderately active young adults” (Knudson, Bennett, Corn, Leick, & Smith, 2001, p. 98). The subjects were tested two times, with a week between each testing day. This helped to ensure that the testing was performed at a similar time of day, with similar subject activity prior to testing, and also enforced that the biomechanics of the subjects’ jumps had not changed. The subjects were randomly selected for the two different warm-up routines which consisted of a control or stretching. Sagittal plane video (60 Hz) of three countermovement jumps were
collected. For the countermovement jumps, subjects played their hands on their hips. All routines began with the taping of 13-mm diameter retroreflective markers to the fifth metatarsal, lateral malleolus, lateral epicondyle of the femur, greater trochanter, and the acromion process. Researchers investigated the acute effect of stretching on the kinematics of the vertical jump after the two warm-up routines were performed and found the MANOVA verified a non-significant (F= 1.39, p= 0.25) effect of performing static stretches prior to a vertical jump.

In a study performed by Christensen and Nordstrom (2008), sixty-eight male and female NCAA Division I athletes from North Dakota State University were evaluated to see the effects of three different warm-ups on vertical jump performance. The three different warm-ups included a 600-m jog, a 600-m jog and a dynamic stretching routine, and a 600-m jog followed by a proprioceptive stretching routine (Christensen & Nordstrom, 2008). The subjects were counterbalanced and randomized into warm-up conditions. Researchers found no substantial evidence of the vertical jump being affected for either gender as the results all of the warm-up protocols were comparable.

In another study conducted by Koch et al. (2003) researchers studied 32, college-aged men (16) and women (16) and the effects of four warm-up routines on a standing broad jump. The purpose of the study was to observe the possible positive or negative effects of stretching, high-force, and high-power warm-ups on the standing broad jump among moderately trained and well-trained subjects (Koch et al., 2003). Additionally, researchers evaluated the relationship between a 1RM squat (strength) and jump performance. Of the 32 participants, 21 (8 men, 13 women) were untrained, healthy, and enrolled in a 6-week weight training course. The other 11 subjects (8 men, 3 women) were sprinters and jumpers from their Division I University’s track team, who had extensive experience in strength training. All subjects were randomized to
complete each of the four warm-up conditions. The warm-up protocols consisted of high power, high force, stretching, or no activity. The high force warm-up included sets of low-repetition squats performed at a relatively high performed of 1RM. Subjects performed 1 set of 3 repetitions in the squat at intensities of 50, 75, and 87.5 % of 1RM with three-minute rest intervals between sets. The high power warm-up consisted of sets of low-repetition speed squats performed explosively at a lower percentage of 1RM. The protocol for this routine consisted of 1 set of 3 repetitions in the speed squat at relative intensities of 20, 30, and 40% of 1RM (Koch et al., 2003). Three-minute rest intervals were given between sets. The stretching condition was comprised of 8 minutes of a variety of static stretching exercises, each performed with a 10-second hold at the position of the greatest stretch. The specific exercises included standing toe touch, standing quadriceps stretch, seated toe touch, and seated quadriceps stretch. The no-activity warm-up consisted of an initial 8 minutes of quiet sitting with no stretching, jumping, or other activity modalities, followed by 3 initial jumps, another 15 minutes of no-activity, and then another 3 jumps. All subjects had performed standing broad jump drills as part of their training for several weeks prior to the study and were accustomed to the movement (Koch et al., 2003). Subjects completed each of the 4 warm-up conditions and broad jump tests as assigned randomly. Researchers used a repeated measures ANCOVA and found no effect on the performance of a broad jump following any of the warm-up conditions. Pearson’s product moment correlation did uncover a strong relationship between performing 1RM squat and broad jump performance.

Dynamic Warm-up or Movement

Dynamic warm-ups or movements have become a common practice amongst many coaches to prepare the athletes to engage in practice or competition (Holt & Lambourne, 2008).
Dynamic warm-up, which is also commonly referred to as dynamic movement or stretching, is defined as “performing movements that take the limb through the range of motion by contracting the agonist muscle, allowing the antagonist muscle to relax and elongate” (Holt & Lambourne, 2008, p. 226). These movements, which consist of various and rhythmic exercises, have demonstrated a greater metabolic and cardiovascular change (Bishop, 2003; Manoel, Harris-Love, Danoff, & Miller, 2008). Manoel et al. (2008) studied the acute effects of static, dynamic, and proprioceptive neuromuscular facilitation (PNF) stretching on muscle power in women. Twelve healthy and recreationally active women from the Georgetown University were recruited to participate. Subjects were available for testing on 4 separate days, with at least 48 hours between test days to ensure they received adequate recovery. On each testing day, the subjects first completed a 5-minute aerobic warm-up at 50W on a stationary cycle ergometer before initial isokinetic testing (Manoel et al., 2008). Subjects were randomly assigned to perform a static stretch, dynamic stretch, PNF stretch, or no-stretch control application. The order of the warm-up condition was systematically varied. The results of this study showed that when percentage changes in power output was analyzed, the dynamic stretch protocol resulted in a percentage change of almost 9%, which was statistically higher than the percentage change for all of the other stretching techniques.

The purpose of a dynamic warm-up is to have continuous movement to prepare the individual for the physical demands of one’s sport or activity (Bishop, 2003; McNillian, Moore, Hatler, & Taylor, 2006). “Dynamic warm-ups have indicated improvements to power output during concentric resistance contractions and vertical jump performance” (Hough, Ross, & Howatson, 2009, p. 507). Additionally, due to the developed motor unit excitability, researchers have seen improvements in neuromuscular performance after engaging in a dynamic warm-up.
(Dalrymple, Davis, Dwyer, & Moir, 2010). This improvement is due to the fact that these dynamic movements assist in increased flexibility through the stimulation of Golgi Tendon organs (Bishop, 2003). As a benefit, the dynamic warm-up prepares an individual’s muscles and joints for the repeated movements their bodies will go through during practice or competition for their sport. Furthermore, evidence has suggested that the increase in body and muscle temperature has been found to increase nerve conduction velocity, enzymatic cycling and increase muscle compliance (Bishop, 2003; Young & Behm, 2002).

There have been a number of mechanisms proposed by which dynamic stretching improves muscular performance. These mechanisms include elevated muscle and body temperature, (Fletcher & Jones, 2004), post-activation potentiation in the stretched muscle caused by voluntary contractions of the antagonist (Hough & Howatson, 2009; Torres et al. 2008), stimulation of the nervous system and/or decreased inhibition of antagonist muscles (Jaggers, Swank, Frost, & Lee, 2008; Yamaguchi & Ishii, 2005). As a result of these effects, dynamic stretching may enhance force and power development (Behm & Chaouachi, 2010; Hough & Howatson, 2009; Torres et al., 2008).

However, several studies have found that dynamic warm-ups did not have a facilitative affect. In studies conducted by Christensen and Nordstrom (2008), Edwards et al. (1972), and Sargeant (1987) researchers found contradicting data on how performing a dynamic warm-up prior to activity affected performance. Christensen and Nordstrom (2008) observed no substantial differences in the performance of a vertical jump after completion of three different warm-up conditions. Edwards et al. (1972) found substantially decreased endurance times for heated muscles. Additionally, Sargeant (1987) also found an increased rate of fatigue as well as a faster rate of a decrease in performance.
Vertical Jump as a Measurement of Power Output

The vertical jump test is a common and valid measure of power output (Church, Wiggins, Moode, & Crist, 2001). This action embodies a ballistic movement that captures maximal explosive power (Bosco, Luhtanen, & Komi, 1983). “The vertical jump has many derivations that enable information to be gathered about various neuromuscular and performance qualities of an individual” (Cronin, Hing, & McNair, 2004, p. 590).

Vertical jump is generally measured by the use of a Force Plate, Jump Mat or Vertec apparatus. “A force plate is designed to measure the forces and movements applied to its top surface as a subject stands, steps, or jumps on it” (AMTI Website, para. 1). Force plates are frequently used in research studies to evaluate a subject’s balance, gait, and sports performance. The methodology of using a force plate was been “typically utilized to compare performance among various types of body weight jumps or to monitor vertical jump performance following an intervention rather than examining the influence of various loads on power output” (Cormie, McBride, & McCaulley, 2007).

Athletic movements such as jumping and cutting are more powerful if an athlete initiates the movement with a countermovement or preparatory descent before the leap (Ford et al., 2005; Newton & Kraemer, 1994). This plyometric action, in which the muscle is stretched before a rapid shortening to accelerate the body or a limb, is termed the stretch-shortening cycle (SSC) (Steben & Steben, 1981). A countermovement jump begins with the body in an upright standing position, followed by a gradual lowering of the body’s center of mass until approximately 45 degrees of knee and hip flexion is reached (Burkett, Phillips, & Ziuraitis, 2005). It is at this point that the upward motion of the jump, the push-off phase, is executed. The jump is completed with both feet landing at the same time (Bobbert, 1990).
The Validity of Using Force Plates as a Measure of Vertical Jumping

Force plates, such as the AMTI force plate are regarded as a reliable and valid measurement of the vertical jump. Validity of a force plate has been previously demonstrated and is considered the “gold standard” reference method for the measurement of vertical jump height (Buckthorpe, Morris, & Folland, 2011; Hatze, 1998; Vanrenterghem, De Clercq, & Van Cleven, 2001). Portable force plate devices were found to be valid measures of vertical jump performance, producing on average, measurements within 1cm or 2% of those using the criterion device (Buckthorpe, Morris, & Folland, 2011). Force plates enable the assessment of force and power production throughout both the eccentric and concentric phases of the movement (Buckthorpe, Morris, & Folland, 2011; Cormie, McGuigan, & Newton, 2010).

Summary

Dynamic and static warm-ups are commonly used variations utilized to prepare athletes for the rigors of sport performance and training. While both warm-ups have been shown to elevate the body’s core temperature and performing movements that put the body through a full range of motion, the focal point is on when is the appropriate time to utilize these warm-ups. The evidence shown above in various studies has indicated that static stretching or warm-ups can have a negative effect on power output measures, such as in a vertical jump test. On the contrary, dynamic warm-ups have the opposite effect and have been shown to positively affect power output tests, such as the vertical jump. However, there are also studies that found the various warm-up did not have a significant impact of performance. Force plates have been found to be a valid measure for assessing vertical jumping. In conclusion, each warm-up can have a positive effect on the body, but the application and prescription of each designated warm-up can be crucial to specific performance movements.
CHAPTER III. METHODOLOGY

Experimental Design

The design for this study was an experimental repeated measures design. This design was used to investigate the effects of four different warm-ups (static stretching, dynamic medicine ball, mini-band, and control) on a lower body power output test. A modified counterbalanced design for the warm-up applications and testing was used. The dependent variable for the lower body power output test was the vertical jump. The independent variables in this particular study were the four warm-up applications. Each participant performed one of the four warm-up applications each day, followed by three vertical jumps. The vertical jump was measured using a force plate. Vertical jump performance was recorded in centimeters (cm). The best score of the three jumps was used in the statistical analysis.

Subjects

A convenient sample of approximately 23 healthy, Division 1 women’s soccer players, ages 18 to 22 years, were recruited to participate in this study. Subjects who have had a significant knee (ACL, MCL tear), ankle, or back injury were excluded from the study. Individuals who were sick within 48 hours of testing (flu like symptoms) as notified by an athletic trainer or team physician were excluded from the study.

This research proposal was approved by the North Dakota State University Institutional Review Board (see Appendix A). All subjects attended an informative presentation describing the study and demonstrating the warm-up applications and test. Additionally, each subject signed an informed consent prior to participating in this study (see Appendix B).
Procedures

The study began on Day 1 with an informative presentation describing the conditions of the study, acquiring informed consent, adaptation with the protocol testing, and demonstrations of the warm-ups (see Table 1). The subjects were randomized into four groups for the study. Days 2-5 consisted of testing. Testing was conducted four times, over the course of two weeks on Monday and Wednesday at 7:00pm and 7:30pm. Testing occurred at North Dakota State University’s Shelly Ellig Indoor Track and Field Complex. All data was recorded on a data collection sheet (Appendix C). The subjects came in for testing in two flight times. Flight I consisted of groups 1 and 2, and flight II consisted of groups 3 and 4. Each group performed their warm-up application for the day followed by the testing protocol. This procedure remained consistent throughout the duration of the study to ensure equivalent testing times for the duration of the whole study.

Table 1

*The modified incomplete counter-balancing scheme for the warm-up procedures*

<table>
<thead>
<tr>
<th>Group</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mini-Bands</td>
<td>Medicine Ball</td>
<td>Static Stretching</td>
<td>Control</td>
</tr>
<tr>
<td>2</td>
<td>Medicine Ball</td>
<td>Mini-Band</td>
<td>Control</td>
<td>Static Stretching</td>
</tr>
<tr>
<td>3</td>
<td>Static Stretching</td>
<td>Control</td>
<td>Medicine Ball</td>
<td>Mini-Bands</td>
</tr>
<tr>
<td>4</td>
<td>Control</td>
<td>Static Stretching</td>
<td>Mini-Bands</td>
<td>Medicine Ball</td>
</tr>
</tbody>
</table>

The warm-ups involved a number of different exercises (see Table 2 and Appendix D). The control group started their 5 minute jog once the other group had completed their 5 minute jog and initiated their assigned warm-up application. This ensures all of the groups began testing at the same time. Once the groups completed their warm-up they had a timed 2 minute break to get water and proceed to their designated testing.
Table 2

The activities completed for each warm-up condition

<table>
<thead>
<tr>
<th>Control Warm-Up</th>
<th>Mini-Band Warm-Up</th>
<th>Medicine Ball Warm-Up</th>
<th>Static Stretching Warm-Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 minute jog</td>
<td>Band Above Knees</td>
<td>Counterbalanced Squat</td>
<td>Performed on both right and left sides</td>
</tr>
<tr>
<td></td>
<td>Bodyweight Squats</td>
<td>Overhead Chops</td>
<td>Groin</td>
</tr>
<tr>
<td></td>
<td>Band Below Knees</td>
<td>Forward Lunge with</td>
<td>Hip Flexor</td>
</tr>
<tr>
<td></td>
<td>Monster walks</td>
<td>Twist Over Knee</td>
<td>Lunge</td>
</tr>
<tr>
<td></td>
<td>Over-Stride Slide</td>
<td>Floor pass</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Band Around Ankles</td>
<td>Counterbalance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Straight Leg</td>
<td>Romanian Deadlift (RDL)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Walks Forward &amp; Backwards</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Straight Leg</td>
<td>Side Slams</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Walks Lateral</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Band Around Feet</td>
<td>Reverse Lunge with</td>
<td>Standing</td>
</tr>
<tr>
<td></td>
<td>Hip Flexion</td>
<td>Bend Over Knee</td>
<td>Gastrocnemius</td>
</tr>
<tr>
<td></td>
<td>Hip Rotation</td>
<td></td>
<td>Arm across body</td>
</tr>
</tbody>
</table>

This study was part of a larger study involving three different researchers, each with their own testing station and equipment. The testing stations are shown in Table 3. Once all of the groups reached their designated testing stations, the testing began at the same time with the first delegated test. Table 4 below provides the test procedures in order for each group for the duration of the study.
Table 3

Testing stations

<table>
<thead>
<tr>
<th>Testing Stations</th>
<th>Testing Instruments</th>
<th>Researcher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Testing Station I:</td>
<td>Vertical Jump</td>
<td>AMTI Force Plate</td>
</tr>
<tr>
<td></td>
<td>BOMB Throw</td>
<td>Martin 165ft/50m Tape Measure</td>
</tr>
<tr>
<td></td>
<td>10/20 m Sprint</td>
<td>Brower Speedtrap 2 Timing System</td>
</tr>
<tr>
<td>Testing Station II:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>T-Test</td>
<td>Brower Speedtrap 2 Timing System</td>
</tr>
</tbody>
</table>

Table 4

Test procedures

<table>
<thead>
<tr>
<th>Group</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BOMB, 20 M, VJ, T-Test</td>
<td>20M, BOMB, T-Test, VJ</td>
<td>VJ, T-Test, BOMB, 20M</td>
<td>T-Test, VJ, 20M, BOMB</td>
</tr>
<tr>
<td>2</td>
<td>20 M, BOMB, T-Test, VJ</td>
<td>BOMB, VJ, 20 M, T-Test</td>
<td>T-Test, 20M, VJ, BOMB</td>
<td>VJ, T-Test, BOMB, 20 M</td>
</tr>
<tr>
<td>3</td>
<td>VJ, T-Test, BOMB, 20 M</td>
<td>T-Test, 20M, VJ, BOMB</td>
<td>20 M, BOMB, T-Test, VJ</td>
<td>BOMB, 20 M, VJ, T-Test</td>
</tr>
<tr>
<td>4</td>
<td>T-Test, VJ, 20M, BOMB</td>
<td>VJ, T-Test, BOMB, 20 M</td>
<td>BOMB, VJ, 20 M, T-Test</td>
<td>20M, BOMB, T-Test, VJ</td>
</tr>
</tbody>
</table>

After the completion of the first test, the participants had a recovery period of two minutes before moving on to the next testing station. After the completion of the second test, the groups had another recovery period of two minutes before moving on to the next designated
testing station. After completion of the third test, the groups received another recovery period of two minutes before moving on to the last designated testing station.

**Instrumentation**

Testing station I utilized an Advanced Medical Technology Inc. (AMTI) Force Plate (Watertown, MA) to test a counter-movement vertical jump. To perform the movement, subjects’ stood with feet hip width apart, with their knees slightly bent. The subjects’ arms were naturally relaxed and hanging at their sides. When ready, subjects moved down into a squat position, throwing their arms back to load their hips, and started their upward ascent by throwing their arms as they jump. Subjects were asked to land naturally and not attempt to keep their legs up in the air.

Testing station II utilized the Martin 165ft/ 50m tape measure secured and taped to the ground. Participants threw a 4.0 kilogram (kg) medicine ball backwards and overhead. This movement consists of having the subjects’ stand on the zero “0” measurement line, with their feet hip width apart, with the medicine ball straight on in front of the subject with the medicine ball at shoulder level. The throwing movement was initiated by a countermovement that consists of the subject flexing at the hips and knees, trunk flexing forward, lowering the medicine ball to below hip height. After the countermovement, the subject drove the hips vertically, swinging the arms up, releasing the ball as the arms are coming overhead around head height (Stockbrugger, & Haennel, 2001). The throw was measured where the ball landed by the measuring tape. The BOMB throw has been shown to be a valid and reliable test of total body power as found in present research (Stockbrugger, & Haennel, 2001; Hankey, & Duncan, 2010).

The 20 m sprint was measured in seconds utilizing the Brower Speed Trap 2 Timing System (Brower Timing Systems, Draper, UT). The subjects lined up on the start line in a two-
point runner’s stance. The timing was started by the researcher on the subjects’ initial movement. The timing was stopped when the subject passes through the electronic gates at the 20 m line. Current research has regarded The Brower Timing System as a valid and reliable test (Shalfawi, Enoksen, Tonnessen, & Ingebrigtsen, 2012).

Testing station III utilized the Brower Speed Trap 2 Timing System (Brower Timing Systems, Draper, UT) to test the T-agility test. The T-agility Test (TAT) was used to measure agility during direction changes such as forward sprints, left and right shuffles, and back-pedaling (Miller, Herniman, Richard, Cheatham, & Michael, 2006). The set up for this test included having three cones set 5 yards apart on a straight line and a fourth cone placed 10 yards from the middle cone, forming a T-Shape (Shimi, Abedelmalek, Aloui, Chtourou, & Souissi, 2016). The participants started at the bottom of the T, sprinted straight ahead 10 yards to the middle cone, shuffled to the right cone for 5 yards, shuffled to the far left cone for 10 yards, shuffled to the right to the middle cone for 5 yards, then backpedaled 10 yards through the bottom or start cone to finish.

The timing was started as soon as the participant moved, and was stopped when the subject passed through the electronic gates. Current research has regarded The Brower Timing System as a valid and reliable test (Shalfawi, et al., 2012). Pauole et al. (2000), the T-agility test has shown this test to be a valid and reliable measure of agility, leg power, and leg speed in college-age men and women.

**Statistical Analysis**

The best vertical jump after each warm-up was used for statistical analysis with an alpha level of p<.05. A one-way repeated measure analysis of variance (ANOVA) was used to test for significant difference in the vertical jumps between the warm-up conditions. If the ANOVA was
found to be significant, there were follow up testing using Bonferroni corrected pair-wise comparisons. Statistical Package for the Social Sciences (SPSS) version 22 was used to complete the statistical analyses.
CHAPTER IV. MANUSCRIPT FOR PUBLICATION: THE EFFECTS OF A MINI-BAND WARM-UP, A MEDICINE BALL WARM-UP AND ASTATIC STRETCHING ON LOWER BODY POWER

Abstract

The Effects of a Mini-Band Warm-up, A Medicine Ball Warm-up and Static Stretching on Lower Body Power. The purpose of this study was to investigate the effects of four different warm-ups on vertical jump performance. The warm-ups included a static stretching routine, dynamic medicine ball routine, mini-band routine, and a 5-minute jog which was the control. The subjects were 23 NCAA Division 1 women’s soccer players from North Dakota State University who performed three vertical jumps on an Advanced Medical Technology Inc. (AMTI) Force Plate after each of the four warm-up routines. The subjects were randomized into four groups for the study and rotated between four warm-up routines, completing one routine each day in a random order. The one-way repeated measures analysis of variance was significant (F=7.87, p=0.007). Follow-up pairwise comparisons showed that the static stretching condition and the control/jog were significantly different (t=-5.15, p<0.001); the static stretching resulted in a significantly lower vertical jump than the control condition.

Key Words vertical jumping, static stretching, dynamic warm-up, mini-band warm-up, medicine ball warm-up, lower body power

Introduction

It is a common practice to perform a warm-up before activity because it has been shown to improve performance as well as possibly decrease the risk of injury. (Hough, Ross, & Howatson, 2009). The purpose of an active warm-up is to help the athletes increase performance by raising the core temperature of their body (Bishop, 2003). Increased heart and metabolic rates help to improve transportation of oxygen and fuel to the muscle tissues. In addition, warm-ups
increase rates of glycolysis and high energy phosphate degradation, moreover, facilitate the rate of nerve conduction which help the rate of obtaining muscle contraction (Brown, Hughes, & Tong, 2008; Febbraio, Carey, Snow, Stathis, & Hargreaves, 1996; Bishop, 2003; Fletcher, 2010). There are two most commonly known and debated forms of warm-ups.

The first, and most commonly identified form of warming the body up, is known as static stretching. This form of stretching was often believed to aid in performance increases and injury decreases. Static stretching has been used for decades, but has recently been a hot topic of discussion of whether it is as truly effective as once claimed. Static stretching has been found to be effective in causing an acute increase in the range of motion (ROM) at a joint (Young, & Behm, 2002). However, it has been found that static stretching can produce a significant acute decrement, of approximately 5-30% in strength and power production of the stretched muscle groups (Young, & Behm, 2002; Cornwell, Nelson, & Sidaway, 2002). On the contrary, new research has shown that injury prevention is doubtful; while the components of strength, power, speed, and jump performance are being negatively impacted, or decreasing (Fletcher, 2010).

A second warm-up that has been frequently used in recent years is termed dynamic or active stretching or movement. Dynamic stretching is defined as “controlled movements through the active joint range of motion for each joint” (Fletcher & Jones, 2004, p. 885). Dynamic or active movements include exercise and are prone to induce a greater metabolic and cardiovascular change (Bishop, 2003). Performing dynamic stretches in a warm-up has been shown to result in an increase in performance (Fletcher, 2010). Researchers have compared and contrasted the results of static and dynamic stretching or movement patterns and positive performance increases have been associated with utilizing these components in a warm-up (Holt & Lambourne, 2008). When compared to static movements, dynamic stretching out-performs its
static counterpart in high intensity, short duration, performance, and muscular function tests
(Faigenbaum, Bellucci, Bernieri, Bakker, & Hoorens, 2005).

However, there are also several research studies that have found no effect on lower body power output tests, such as the vertical jump. In a study conducted by Knudson, Bennett, Corn, Leick, and Smith (2001), researchers studied 20 young adult volunteers, 10 male and 10 female. The subjects were tested two times, with a week between each testing day. Subjects were randomly selected for the two different warm-up routines which consisted of a control or stretching. Researchers investigated the acute effect of stretching on the kinematics of the vertical jump after two warm-up routines were performed and found no significant effect of performing static stretches prior to a vertical jump.

In a study performed by Christensen and Nordstrom (2008), 68 male and female NCAA Division I athletes were evaluated to see the effects of three different warm-ups on vertical jump performance. The three different warm-ups included a 600-m jog, a 600-m jog and a dynamic stretching routine, and a 600-m jog followed by a proprioceptive stretching routine (Christensen & Nordstrom, 2008). The subjects were counterbalanced and randomized into warm-up conditions. Researchers found no substantial evidence of the vertical jump being affected for either gender as the results all of the warm-up protocols were comparable.

Additionally, in another study conducted by Koch et al. (2003) researchers studied 32 college-aged men and women and the effects of four warm-up routines on a standing broad jump. Of the thirty-two subjects, twenty-one were untrained, healthy, and enrolled in a 6-week weight training course. The other 8 subjects were sprinters and jumps from their Division I University’s track team, who had extensive experience in strength training. The warm-up protocols consisted of high power, high force, stretching, or no activity. All subjects were
randomized to complete each of the four warm-up conditions. Researchers found no effect on the performance of a broad jump.

The vertical jump test is a common and valid measure of power output (Church, Wiggins, Moode, & Crist, 2001). This action embodies a ballistic movement that captures maximal explosive power (Bosco, Luhtanen, & Komi, 1983). “The vertical jump has many derivations that enable information to be gathered about various neuromuscular and performance qualities of an individual” (Cronin, Hing, & McNair, 2004, p.590). Vertical jump is generally measured by the use of a Force Plate, Jump Mat, or Vertec.

**Experimental Approach to the Problem**

The design for this study was an experimental repeated measures design. This design was used to investigate the effects of four different warm-ups (static stretching, dynamic medicine ball, mini-band, and control) on a lower body power output test. A modified counterbalanced design for the warm-up applications and testing was used. The dependent variable for the lower body power output test was the vertical jump. The independent variables in this particular study are the four warm-up applications. Each participant performed one of the four warm-up applications each day, followed by three vertical jumps. The vertical jump was measured using a force plate. Vertical jump performance was recorded in centimeters (cm). The best score of the three jumps was used in the statistical analysis. All the athletes participated in the warm-up condition in a modified counterbalanced random order.

**Subjects**

A convenience sample of 23 healthy, Division 1 women’s soccer players ages to 18 to 22 years old from North Dakota State University were involved. The study and informed consent form were approved by the North Dakota State University Institutional Review Board. The
subjects read and signed an informed consent document. All of the athletes in the study were involved in an Olympic lift-based resistance training program.

**Procedures**

The countermovement vertical jump was measured using the Advanced Medical Technology Inc. (AMTI) Force Plate. The force plate is a metal plate with one or more sensors attached to give an electrical output proportional to the force on the plate (Cross, 1998). Validity of a force plate has been previously demonstrated and is considered the “gold standard” reference method for the measurement of vertical jump height (Buckthorpe, Morris, & Folland, 2011; Hatze, 1998; Vanrenterghem, De Clercq, & Van Cleven, 2001). The results from all testing sessions were recorded on a spreadsheet developed in Microsoft Excel (Microsoft Corporation, Redmond, Wash.).

The subjects were randomized into four groups for the study (see Table 5). Additionally, the subjects came in for testing on Monday and Wednesday in two flight times at 7:00pm and 7:30pm. Flight I consisted of groups 1 and 2, and flight II consisted of groups 3 and 4. Four groups were used to ensure there would not be too many subjects at any one testing session and there would not be too long of a time between jumps. It needs to be noted that this study was part of a larger involving three different researchers, each with their own testing station and equipment.

Table 5

*The modified incomplete counter-balancing scheme for the warm-up procedures*

<table>
<thead>
<tr>
<th>Group</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mini-Bands</td>
<td>Medicine Ball</td>
<td>Static Stretching</td>
<td>Control</td>
</tr>
<tr>
<td>2</td>
<td>Medicine Ball</td>
<td>Mini-Band</td>
<td>Control</td>
<td>Static Stretching</td>
</tr>
<tr>
<td>3</td>
<td>Static Stretching</td>
<td>Control</td>
<td>Medicine Ball</td>
<td>Mini-Bands</td>
</tr>
<tr>
<td>4</td>
<td>Control</td>
<td>Static Stretching</td>
<td>Mini-Bands</td>
<td>Medicine Ball</td>
</tr>
</tbody>
</table>
The warm-ups involved a number of different exercises (see Table 6). The control group started their 5 minute jog once the other group has completed their 5 minute jog and initiated their assigned warm-up application. This ensures all of the groups began testing at the same time. Once the groups completed their warm-up they have a timed 2 minute break to get water and proceed to their designated testing.

Table 6

*The activities completed for each warm-up condition*

<table>
<thead>
<tr>
<th>Control Warm-Up</th>
<th>Mini-Band Warm-Up</th>
<th>Medicine Ball Warm-Up</th>
<th>Static Stretching Warm-Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 minute jog</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Band Above Knees</td>
<td>Bodyweight Squats</td>
<td>Counterbalanced Squat</td>
<td>Overhead Chops</td>
</tr>
<tr>
<td>Band Below Knees</td>
<td>Monster walks</td>
<td>Forward Lunge with</td>
<td>Groin</td>
</tr>
<tr>
<td></td>
<td>Over-Stride Slide</td>
<td>Twist Over Knee</td>
<td></td>
</tr>
<tr>
<td>Band Around Ankles</td>
<td></td>
<td>Floor pass</td>
<td></td>
</tr>
<tr>
<td>Straight Leg</td>
<td></td>
<td>Counterbalance</td>
<td>Lying Glute</td>
</tr>
<tr>
<td>Walks Forward</td>
<td>Romanian Deadlift (RDL)</td>
<td></td>
<td>Lying Quad</td>
</tr>
<tr>
<td>&amp; Backwards</td>
<td></td>
<td></td>
<td>Seated</td>
</tr>
<tr>
<td>Straight Leg</td>
<td></td>
<td></td>
<td>Hamstring</td>
</tr>
<tr>
<td>Walks Lateral</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Band Around Feet</td>
<td></td>
<td>Reverse Lunge with</td>
<td>Standing</td>
</tr>
<tr>
<td>Hip Flexion</td>
<td></td>
<td>Bend Over Knee</td>
<td>Gastrocnemius</td>
</tr>
<tr>
<td>Hip Rotation</td>
<td></td>
<td></td>
<td>Arm across body</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Arm behind head</td>
</tr>
</tbody>
</table>

This study was part of a larger study involving three different researchers, each with their own testing station and equipment. The testing stations are shown in Table 7. Once all of the groups reached their designated testing stations, the testing began at the same time with the first
delegated test. Table 8 below provides the test procedures in order for each group for the duration of the study.

Table 7

*Testing stations*

<table>
<thead>
<tr>
<th>Testing Stations</th>
<th>Testing Instruments</th>
<th>Researcher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Testing Station I:</td>
<td></td>
<td>Researcher I</td>
</tr>
<tr>
<td>Vertical Jump</td>
<td>AMTI Force Plate</td>
<td></td>
</tr>
<tr>
<td>Testing Station II:</td>
<td></td>
<td>Researcher II</td>
</tr>
<tr>
<td>BOMB Throw</td>
<td>Martin 165ft/50m Tape Measure</td>
<td></td>
</tr>
<tr>
<td>10/20 m Sprint</td>
<td>Brower Speedtrap 2 Timing System</td>
<td></td>
</tr>
<tr>
<td>Testing Station III:</td>
<td></td>
<td>Researcher III</td>
</tr>
<tr>
<td>T-Test</td>
<td>Brower Speedtrap 2 Timing System</td>
<td></td>
</tr>
</tbody>
</table>

Table 8

*Test procedures*

<table>
<thead>
<tr>
<th>Group</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BOMBT, 20 M, VJ, T-Test</td>
<td>20 M, BOMBT, T-Test, VJ</td>
<td>VJ, T-Test, BOMBT, 20 M</td>
<td>T-Test, VJ, 20 M, BOMBT</td>
</tr>
<tr>
<td>2</td>
<td>20 M, BOMBT, T-Test, VJ</td>
<td>BOMBT, VJ, 20 M, T-Test</td>
<td>T-Test, 20 M, VJ, BOMBT</td>
<td>VJ, T-Test, BOMBT, 20 M</td>
</tr>
<tr>
<td>3</td>
<td>VJ, T-Test, BOMBT, 20 M</td>
<td>T-Test, 20 M, VJ, BOMBT</td>
<td>20 M, BOMBT, T-Test, VJ</td>
<td>BOMBT, 20 M, VJ, T-Test</td>
</tr>
<tr>
<td>4</td>
<td>T-Test, VJ, 20 M, BOMBT</td>
<td>VJ, T-Test, BOMBT, 20 M</td>
<td>BOMBT, VJ, 20 M, T-Test</td>
<td>20 M, BOMBT, VJ, T-Test</td>
</tr>
</tbody>
</table>

After the completion of the first test, the participants had a recovery period of 2 minutes before moving on to the next testing station. After the completion of the second test, the groups
had another recovery period of 2 minutes before moving on to the next designated testing station. After completion of the third test, the groups received another recovery period of 2 minutes before moving on to the last designated testing station.

**Statistical Analysis**

The best vertical jump after each warm-up was used for statistical analysis with an alpha level of \( p < .05 \). The results were recorded in centimeters. A one-way repeated measure analysis of variance (ANOVA) was used to test for significant differences in the vertical jumps between the warm-up conditions. If the ANOVA was found to be significant, follow up testing using Bonferroni corrected pair-wise comparisons was conducted with an alpha level of \( p < .008 \).

Statistical Package for the Social Sciences (SPSS) version 22 was used to complete the statistical analyses.

**Results**

The ANOVA was found to be statistically significant (\( p = 7.87, \ p = 0.007 \)). The results from worst to best performances and average: static stretching (32.09±2.98cm), mini-band (32.65±3.67m), medicine ball (33.03±3.40cm), and control (33.85±3.41cm). Because the ANOVA results were significant, follow-up Bonferroni corrected pair-wise comparisons were conducted. Paired sample t-test results showed that there was a significant difference between the static stretching and control applications (\( t = -5.15, \ p < .001 \)). The static stretching warm-up resulted in a lower VJ than the warm-up condition.

**Discussion**

Based on the results of other similar studies, we hypothesized that the static stretching application would result in a decrease in performance in the vertical jump. Church et al. (2001) investigated the effect of warm-up and flexibility treatments on vertical jump performance and
found a significant decrease in vertical jump performance after performing proprioceptive neuromuscular facilitation (PNF) stretching. Holt and Lambourne (2008), investigated the impact of different warm-up protocols on vertical jump performance in male collegiate athletes. They found that the results were consistent with current evidence suggesting that static stretching in a warm-up application can have a negative effect on power performance, specifically vertical jump performance. Their results do not agree with our results, we found no difference between static stretching and our other dynamic warm-ups. Additionally, Faigenbaum et al. (2005) examined the acute effects of different warm-up protocols on fitness performance in children and found that static stretching prior to a vertical jump resulted in a substantial decrease in performance.

In contrast, our results did not agree with McMillian et al., (2006) who researched dynamic vs. static-stretching warm-ups and the effect they had on power and agility performance. Results of this particular study found a considerable improvement in a 5-step jump test performed after a static-stretching warm-up in comparison to a no warm-up condition.

Comparable to the findings of our present study, Unick, Kieffer, Cheesman, and Feeney (2005) studied the acute effects of static and ballistic stretching on vertical jump performance in trained women and found that were no significant differences in vertical jump performance after completing a static or ballistic stretching condition. Christensen & Nordstrom (2008) examined the effects of proprioceptive neuromuscular facilitation (PNF) and dynamic stretching techniques on vertical jump performance and found no sizable difference in vertical jump performance after performing either warm-up application. Their results support our results that a stretching based warm-up and dynamic warm-ups result in no significant differences in vertical jump performance.
During each day of testing, the athletes had also completed mandatory weight training, conditioning, and scheduled practice sessions. Additionally, between the two weeks of testing, the athletes also competed in a soccer match over the weekend as part of their spring season competition. Because of the load and time of year that the study was conducted, these factors could have affected our results.

The sport of soccer not only challenges the athletes’ physical strength and conditioning and their sport-specific skills, but also their ability to sustain these components for the duration of the match. A collegiate soccer match consists of two 45 minute halves, with a 15 minute halftime between halves. Soccer is primarily an aerobic-based sport, however it requires lower body strength and power to change directions as the ball moves across the field. Vertical jumping during the duration of a soccer match is typically only utilized in performing a header, or by goalkeepers attempting to make a save while defending their goal.

**Practical Applications**

Performing a proper warm-up prior to physical activity has generally been considered an important factor in helping to reduce the occurrence of injury, increasing the range of motion about the joints, in addition to keeping the athlete healthy. These components are vital in preparation to perform at the highest level during strength and conditioning workouts, practice, and competition at the collegiate level.

Warm-up conditions are not the end all be all of determining the outcome of performance measures, however, they play an important role in properly preparing the athlete to achieve their highest potential. However, based on the results of this study there were no significant differences between the three warm-ups. The highest mean found was in the control condition possibly indicating that the athletes were fatigued from all the training and games. So it may be
important for a coach to be aware of the amount of training the athletes are doing and decrease warm-ups to prevent fatigue from affecting performance.
CHAPTER V. DISCUSSION AND CONCLUSIONS

Performing a proper warm-up prior to physical activity has been established as an extremely important factor in helping to reduce the occurrence of injury, increasing the range of motion about the joints, in addition to keeping the athlete healthy. These components are vital in preparation to perform at the highest level during strength and conditioning workouts, practice, and competition at the collegiate level.

Based on the results of other similar studies, we hypothesized that the static stretching application would result in a decrease in performance in the vertical jump. However, we found that there was no significant difference in vertical jump performance results amongst the three different warm-up conditions. The reasons for the lack of significant differences between warm-up applications could be contributed to a variety of factors, such as fatigue.

The control group, which comprised of a 5 minute jog resulted in the best mean performance of all the warm-up protocols. The reason for this result could be related to fatigue. The student-athletes that were tested in this study were in the heart of their off-season training and spring competition schedule. The demands of a rigorous strength and conditioning, practice, and competition schedule could have impacted the results of the study. Although we tried to provide an adequate amount of recovery time between testing dates and times in coordination with their structured and diligent schedules, the volume of stressors placed on the body could have influenced their vertical jump performance.

It is vital as strength and conditioning coaches to understand the daily demands that each specific athlete or team has on any given day and structure your warm-ups, and workouts accordingly, to reduce the chance to have decreases in performance. Our role is to create and
foster an environment that is conducive to putting our athletes in the best positions to achieve success and this starts in the warm-up.
REFERENCES


APPENDIX A. INSTITUTIONAL REVIEW BOARD APPROVAL

February 20, 2014

Bryan Christensen
Department of Health, Nutrition & Exercise Sciences
1 BBF

IRB Approval of Protocol #HE14170, "The effects of two different dynamic warm-ups and static stretching on agility, speed, and power output performance"
Co-investigator(s) and research team: Ryan Napoli, Cody Halsey, Kelly Lopez

Approval period: 2/20/14 to 2/19/15 Continuing Review Report Due: 1/1/15

Research site(s): NDSU Funding agency: n/a
Review Type: Expedited category # 4
IRB approval is based on original submission, with revised: protocol (received 2/18/14).

Additional approval is required:
- prior to implementation of any proposed changes to the protocol (Protocol Amendment Request Form).
- for continuation of the project beyond the approval period (Continuing Review/Completion Report Form). A reminder is typically sent two months prior to the expiration date; timely submission of the report is your responsibility. To avoid a lapse in approval, suspension of recruitment, and/or data collection, a report must be received, and the protocol reviewed and approved prior to the expiration date.

A report is required for:
- any research-related injuries, adverse events, or other unanticipated problems involving risks to participants or others within 72 hours of known occurrence (Report of Unanticipated Problem or Serious Adverse Event Form).
- any significant new findings that may affect risks to participants.
- closure of the project (Continuing Review/Completion Report Form).

Research records are subject to random or directed audits at any time to verify compliance with IRB regulations and NDSU policies.

Thank you for cooperating with NDSU IRB procedures, and best wishes for a successful study.

Sincerely,

Kristy Shirley, CIP
Research Compliance Administrator

NDSU NORTH DAKOTA STATE UNIVERSITY

Federal Wide Assurance FWA00002439

INSTITUTIONAL REVIEW BOARD
NDSU Dept 4000 | PO Box 6050 | Fargo, ND 58108-6050 | 701.231.6995 | Fax 701.231.8098 | ndsu.edu/irb

Shipping address: Research, 1735 NDSU Research Park Drive, Fargo, ND 58102

Kristy Shirley, CIP
Research Compliance Administrator
APPENDIX B. INFORMED CONSENT DOCUMENT

NDSU North Dakota State University
Department of Health, Nutrition, and Exercise Sciences
PO Box 6050
Fargo, ND 58108-6050
701-231-6737

Title of Research Study: The effects of two different dynamic warm-ups and static stretching on agility, speed, and power output performance.

This study is being conducted by: Bryan Christensen, PhD, CSCS, Ryan Napoli, Kelly Lopez, and Cody Halsey

Why am I being asked to take part in this research study? You are being asked to participate in this study because: 1) you are a collegiate athlete; 2) you have not had an injury in the last 6 months.

What is the reason for doing the study? The purpose of this study is to determine which type of a warm-up will result in the best performance in power, speed, and agility tests.

What will I be asked to do? You will be asked to come to the BSA on four different evenings. Each of these evenings you will do a 5 minute jog, and then complete one of four different warm-ups (static stretching, a dynamic medicine ball warm-up, a dynamic mini-band warm-up, or a control condition with no warm-up). After the warm-up you will complete four different physical tests that involve vertical jumping, throwing a medicine ball, sprinting 30 meters, and an agility T-test.

Where is the study going to take place, and how long will it take? The study will take place in the Bison Sports Arena. It will take approximately 30 minutes to complete the warm-up and physical tests on each of the four different testing days.

What are the risks and discomforts? The main risks are musculoskeletal injuries. The warm-ups will help minimize the risks. The researchers are experienced conducting these types of warm-ups and physical tests, which will also reduce the risk of injuries.

What are the benefits to me? The results of this research may provide you with information about the best type of warm-up to maximize your performance in training or competition.

What are the benefits to other people? Other people and athletes who are in similar types of activities could also gain information about the best warm-up to maximize performance.

Do I have to take part in the study? Your participation in this research is your choice. If you decide to participate in the study, you may change your mind and stop participating at any time without penalty or loss of benefits to which you are already entitled. Inform one of the researchers immediately if you would like to discontinue the study.
What will it cost me to participate? There is no monetary cost to you. This study will require about 2 total hours of your time.

What are the alternatives to being in this research study? Instead of being in this research study, you can choose not to participate.

Who will see the information that I give? Your name will be documented in a password protected computer that only the researchers will have access to. We will keep private all research records that identify you. Your information will be combined with information from other people taking part in the study. When we write about the study, we will write about the combined information that we have gathered. We may publish the results of the study; however, we will keep your name and other identifying information private. We will make every effort to prevent anyone who is not on the research team from knowing that you gave us information, or what that information is.

Can my taking part in the study end early? If you fail to show up to all the physical testing sessions you may be removed from the study.

What happens if I am injured because of this research? If you receive an injury in the course of taking part in the research, you should contact Dr. Margret Fitzgerald, head of the department of Health, Nutrition, and Exercise Sciences, at the following phone number (701) 231-5590. Treatment for the injury will be available including first aid, emergency treatment and follow-up care as needed. Payment for this treatment must be provided by you and your third party payer (such as health insurance or Medicare). This does not mean that you are releasing or waiving any legal right you might have against the researcher or NDSU as a result of your participation in this research.

What if I have questions? Before you decide whether to accept this invitation to take part in the research study, please ask any questions that might come to mind now. Later, if you have any questions about the study, you can contact the principle investigator, Bryan Christensen at 701-231-6737.

What are my rights as a research participant? You have rights as a participant in research. If you have questions about your rights, or complaints about this research or to report a research-related injury, you may talk to the researcher or contact the NDSU Human Research Protection Program by:

- Telephone: 701.231.8908
- Email: ndsu.irb@ndsu.edu
- Mail: NDSU HRPP Office, NDSU Dept. 4000, PO Box 6050, Fargo, ND 58108-6050.

The role of the Human Research Protection Program is to see that your rights are protected in this research; more information about your rights can be found at: www.ndsu.edu/research/irb.
**Documentation of Informed Consent:**
You are freely making a decision whether to be in this research study. Signing this form means that

1. you have read and understood this consent form  
2. you have had your questions answered, and  
3. you have decided to be in the study.

You will be given a copy of this consent form to keep.

__________________________  ______________________
Your signature               Date

__________________________
Your printed name

__________________________  ______________________
Signature of researcher explaining study  Date

__________________________
Printed name of researcher explaining study
# APPENDIX C. DATA COLLECTION SHEET

**MASTER'S RESEARCH DATA COLLECTION**

<table>
<thead>
<tr>
<th>Name</th>
<th>VERTICAL JUMP</th>
<th>DOOM THROW</th>
<th>10/20 M SPRINT</th>
<th>T-TEST</th>
<th>AVERAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>VERT 1</td>
<td>VERT 2</td>
<td>VERT 3</td>
<td>THROW 1</td>
<td>THROW 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Average**
**APPENDIX D. DESCRIPTION OF THE WARM-UP EXERCISES**

**Mini-Band Warm-ups**

Squat With Band Above Knee- Subject will stand with feet slightly wider than hip width apart, toes slight pointed out, and the mini-band above the knee. Subject will squat down until they have broken parallel, while maintaining an erect chest, flat back, pushing their knees out against the band throughout the entire movement. Subject will repeat this for 10 repetitions.

Monster Walks With Band Below Knee- Subject will stand with feet hip width apart, toes straight ahead, and the mini-band below the knee. Subject will squat down to an athletic stance and will take a big forward step with right leg, maintaining neutral hips, followed by a little step with the trail leg. Subject will maintain a base with the feet with each step, as well as maintaining the same athletic stance throughout the movement. Subject will alternate the forward step foot, each repetition until subject has completed 10 forward steps with each leg. Subject will then perform the same movement backwards. Subject will alternate the backward step foot, each repetition until subject has completed 10 backward steps with each leg.

Overstride Slide With Band Below Knee- Subject will stand with feet slightly wider than hip width apart, toes straight ahead, and the mini-band below the knee. Subject will squat down to an athletic stance and will take a big lateral step to the right, following with a little step with the trail leg. Subject will maintain a base between the feet with each step, as well as maintaining the same athletic stance throughout the movement. Subject will repeat this for 10 repetitions to the right, followed by 10 repetitions to the left.

Straight Leg Forward/Backward Walk With Band Around Ankles- Subject will stand with feet hip width apart, toes straight ahead, and the mini-band around the ankles. Subject will take a big forward step with the right leg, followed by a small step with the trail leg. Subject will
maintain a base with the feet with each step, legs straight, as well as keeping the toes pointed straight ahead. Subject will alternate the forward step foot, each repetition until subject has completed 10 forward steps with each leg. Subject will then perform the same movement backwards for 10 repetitions each leg.

Straight Leg Lateral Walk With Band Around Ankles- Subject will stand with feet hip width apart, toes straight ahead, and the mini-band around the ankles. Subject will take a big lateral step to the right, followed by a little lateral step with the trail leg. Subject will maintain a base with the feet, legs straight, and toes pointed straight ahead. Subject will perform the movement for 10 repetitions to the right, followed with the repeated movement for 10 repetitions to the left.

Hip Flexion With Band Around Feet- Subject will flex hip and knee of one leg to approximately 90 degrees while maintaining good standing position. Subject will perform 10 repetitions on the right leg, followed by 10 repetitions on the left leg.

Hip Rotation With Band Around Feet- Subject will flex hip and knee of one leg to approximately 90 degrees while simultaneously rotating their hip out while maintaining good standing position. Subject will perform 10 repetitions on the right leg, followed by 10 repetitions on the left leg.

**Dynamic Medicine Ball Warm-up**

Counterbalance (CB) Squat- Subject will stand with feet slightly wider than hip width apart, toes slightly pointed out. Arms fully extend out in front, hands in a supine position holding ball. Subject will squat down until they have broken parallel, while maintaining straight arms, an erect chest, flat back, with their knees out. Subject will repeat this for 10 repetitions.
Overhead (OH) Chop- Subject will stand with feet slightly wider than hip width apart and toes slightly pointed out. Subjects’ arms are fully extended above head holding ball. As subject descends into a squat, they will lower the ball down while maintaining straight arms, an erect chest, and a flat back. These two movements will happen simultaneously and the ball will end up in front of the subjects’ feet as the subject breaks parallel in the squat. Subject will repeat this for 10 repetitions.

Forward Lunge With Twist Over Knee- Subject will start standing holding the medicine ball in a supine position with elbows flexed at 90 degrees, erect chest, and flat back. Subject will lunge forward, while simultaneously twisting over the front knee, maintaining most of the weight on the mid-foot of the front leg, as well as an erect chest and stable trunk. Subject will lunge until the back knee hovers just above the ground. The front knee will remain over the heel. Subject will repeat this for 5 repetitions each side (Herman & Smith, 2008).

Floor Pass- Subject will stand upright with feet hip width apart. Holding the ball, the subject will bend the elbows and reach the med ball between the shoulder blades. The subject will then lift the ball up overhead and throw the ball directly down in front of their feet as hard as they can. After releasing the ball the subject will put their hands out at chest level to stop the ball from bouncing too high and to keep the movement repetitive. Subject will repeat this for 10 repetitions.

Counterbalance (CB) Romanian Deadlift (RDL)- Subject will stand with feet hip width apart, knees unlocked, and holding the med ball with arms extended down by their waist. As the subject performs an RDL, by pushing their hips back, maintaining a tight and flat back and unlocked knees, they will reach the med ball out in front of their body with straight arms. Subject will repeat this for 10 repetitions.
Side Slams- Subject will stand with feet hip width apart, knees unlocked, holding the med ball with extended arms down by their waist. Subject will swing med ball in a circular motion out to the side, up overhead, and follow through by throwing it down by the side of the foot they initially started on. Subject will perform all 5 repetitions on one side, and then will perform all 5 repetitions on the other side.

Reverse Lunge With Bend Over Knee- Subject will start standing holding the medicine ball overhead. Subject will lunge behind to the same side as the leg that is forward, while simultaneously bending over the front knee, maintaining most of the weight on the mid-foot of the front leg, as well as an erect chest and stable trunk. Subject will lunge until the back knee hovers just above the ground. The front knee will remain over the heel. Subject will repeat this for 5 repetitions each side (Herman & Smith, 2008).

**Static Stretch Warm-up**

Groin- Subject stands with feet as wide as they can get then. Sit back and squat to the right keeping the opposite leg straight and chest erect. Subject will hold for 15 seconds. Switch and repeat on other side.

Hip Flexor Lunge- Subject begins with a split stance, right leg forward, left leg back. Subject maintains an erect position as they drop the back knee to the ground, while pushing the hips forward. Subject will hold for 15 seconds. Switch and repeat on other side.

Lying Glute- Subject will start in a pushup position and curl one leg underneath them with the knee and foot being perpendicular to the body. The subject will lower their body down until their forearms are on the ground supporting their body. Maintain the hips in a neutral position and are square straight ahead. Subject will hold for 15 seconds. Switch and repeat on other side.
Lying Quad- Subject will lie on right side, extend right arm above head, and lean on for balance. Subject flexes right knee and grasps same ankle of flexed knee and pulls ankle up towards buttocks until a slight stretch is felt in quadriceps. Subject will hold for 15 seconds. Switch and repeat on other side (Dalrymple, Davis, Dwyer, & Moir, 2010).

Seated Hamstring- Subject is sitting upright with their right leg extended and their left foot touching the medial part of their thigh. Subject leans forward and touches toes with both hands, without flexing knees. Subject leans forward until a slight stretch is felt in hamstring. Subject will hold for 15 seconds. Switch and repeat on other side (Dalrymple, Davis, Dwyer, & Moir, 2010).

Standing Gastrocnemius- Subject is in a standing position with feet staggered about 2-3 feet from a wall, place both hands on wall and lean forward; keep the back leg straight with the heel on the floor and the front leg flight bent. Hold for 15 seconds. Switch and repeat on other side (Faigenbaum et al., 2006).

Arm Across Body- Subject is standing and will cross one arm across their body, while holding that arm by their wrist or forearm with the opposite hand. Subject will hold for 15 seconds. Switch and repeat on other side.

Arm Behind Head- Subject is standing and will place one hand over the head between the shoulder blades; grab the bent elbow with the other hand until the subject feels a slight stretch. Subject will hold for 15 seconds. Switch and repeat on other side (Faigenbaum et al., 2006).