

THE EFFECTS OF TWO TYPERS OF DIFFERENT DYNAMIC WARM-UPS AND STATIC  
STRETCHING ON TOTAL BODY POWER AND SPEED

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**Title**

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AND STATIC STRETCHING ON TOTAL BODY POWER AND SPEED

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**MASTER OF SCIENCE**

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## ABSTRACT

Static stretching has often been found to decrease performance in power and speed activities, but dynamic warm-ups usually increase performance. We examined the effects of a mini-band warm-up, a medicine ball warm-up, and static stretching on 10m and 20m sprint times, as well as overhead medicine ball throw performance. A convenience sample of 24 Division I women's soccer players participated, however 5 subjects dropped out due to sustaining injuries from a weekend soccer tournament. The subjects completed the three warm-ups and a control 5 minute jog condition on separate days and were tested on the 10m and 20m sprint times and overhead medicine ball throw. ANOVA's and follow-up paired t-tests ( $p < 0.05$ ) were used to determine differences between the warm-ups. Significant differences were found between groups for the 10m sprint times but not for the 20m sprint times or the overhead medicine ball throw.

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## CHAPTER I. INTRODUCTION

Static stretching has been considered an essential component of warm-ups for decades (Young & Behm 2002). Typically, a warm-up consists of some form of submaximal aerobic exercise with the goal of raising the core body temperature (Young & Behm, 2002; Young, 2007). Another part of the warm-up consists of static stretching (Behm & Chaouachi, 2010). There is a substantial body of past and current research that shows static stretching decreases subsequent performance (Behm, Button, & Butt, 2001; Behm, 2004; Behm & Kibele 2007; Fowles, Sale, & MacDougal, 2000; Kokkonen, Nelson, & Cornwell, 1998; Power, Behm, Cahill, Carroll, & Young, 2004; Behm & Chaouchi 2010).

More recently the active or dynamic warm-up has become increasingly popular and recent literature has shown increases in subsequent performance (Behm & Chaouachi, 2010; Holt & Lambourne, 2008; McMillian, Moore, Halter, & Taylor, 2006). There are primarily two main types of a dynamic warm-up: dynamic stretching and dynamic movement. Dynamic stretching involves controlled movement through the active range of motion for a joint (Fletcher, 2010). Dynamic warm-up involves exercise and is likely to induce greater metabolic and cardiovascular changes than static stretching (Bishop, 2003a). Much of the recent literature has shown the dynamic stretching and active warm-ups induce positive performance benefits (Bishop, 2003a, b; Behm & Chaouachi, 2010; Holt & Lambourne, 2008; McMillian et al., 2006; Young & Behm 2002).

The backwards overhead medicine ball (BOMB) throw has been suggested as an appropriate method to assess total body power (Stockbrugger & Haennel, 2001). This test incorporates the integration of multidimensional movement and multiple musculatures used to generate power (Duncan, Nakeeb, & Nevill, 2005).

Mini band warm-ups have had little research to date, however they are commonly used in collegiate strength and conditioning programs. The theory behind the use of mini bands around the legs is to activate the muscles of the leg and increase the neural drive within those muscles (Cambridge, Sidorkewicz, Ikeda, & McGill, 2012). A study conducted by Cambridge et al., (2012) aimed at examining the effects of altering resistance band placement during 'Monster Walks' and 'Sumo Walks.' The study used 9 healthy male volunteers that formed a convenience sample for this study. The males had a mean age of 22.6 +/- 2.2 years; height of 181.9 +/- 9.2 cm; and weight of 85.8 +/- 15.4 kg. The study used 16 electromyography channels to measure neural drive of selected muscles of the right hip and torso muscles. The researchers used three band placements (around the knees, ankles, and feet) during two exercises (Cambridge et al., 2012). The study used a repeated measures analysis of variance (ANOVA) with Bonferroni adjustment to assess differences in mean EMG. The study found that when examining the muscle activation profiles in the three hip muscles of interest revealed the progressive nature of the neural drive when altering band placement (Cambridge et al., 2012). The tensor fascia latae (TFL) demonstrated a progressive activation moving the band from the knee to the distal placement, but not between the ankle and foot placements (Cambridge et al., 2012). Gluteus medius demonstrated a progressive activation moving distally between placements. Gluteus maximus was preferentially activated only during the foot placement (Cambridge et al., 2012). Medicine ball warm-ups are also used in warm-ups in the collegiate strength and conditioning field. Medicine ball warm-ups involve holding a medicine ball and performing exercises in a controlled manner. Often times the exercises chosen mimic the exercises that the athletes will be performing in their workouts. A medicine ball warm-up can be used to warm-up

all the musculature in the body because of the ability to change where the loading point is. No research has been able to be found on using medicine balls in warm-ups.

The purpose of this study was to determine if the two dynamic warm-ups (medicine ball warm-up and mini-band warm-up) had a significant effect on performance in total body power output tests; and to determine if static stretching had a negative effect on performance in total body power output tests.

### **Research Questions**

1. Did static stretching prior to testing BOMB throw and 20m sprint with 10m split affect performance?
2. Did a medicine ball warm-up prior to testing BOMB throw and 20m sprint with 10m split affect performance?
3. Did a mini-band warm-up prior to testing BOMB throw and 20m sprint with 10m split affect performance?

### **Research Hypothesis**

1. It was hypothesized that static stretching prior to testing BOMB throw and 10 and 20m sprint would result in a performance decrease versus medicine ball, mini-band, dynamic warm-ups, and control warm-ups.

2. It was hypothesized that the medicine ball warm-up would result in a performance increase on the BOMB throw and the 10 and 20m sprint versus static stretching and control warm-ups.

3. It was hypothesized that the mini-band warm-up would result in a performance increase on the BOMB throw and 10 and 20m sprint versus static stretching and control warm-ups.

## **Significance of Study**

Most of the current literature on dynamic warm-ups focuses on the stretching based dynamic warm-up. This study is significant because it aimed to examine two newer types of dynamic warm-ups on power output. This study also is significant because it may demonstrate the performance benefits of the medicine ball warm-up and the mini-band warm-up on power output. Finally, this study is significant because there is little literature examining the mini-band and medicine ball based dynamic warm-ups.

## **Research Design**

The research design was an experimental repeated measures design. The best performance for each test was used for statistical analyses with an alpha level of  $<.05$ . The study used three separate univariate, repeated measures analysis of variance (ANOVA). If the ANOVA was found to be significant, a follow up Bonferroni corrected pair-wise comparisons were conducted.

## **Assumptions**

1. The BOMB throw and 10 and 20m sprint are valid measurements of total body power.
2. The Brower Timing System is a valid measurement of sprint timing (Shalfawi, Enoksen, Tonnessen & Ingebrigtsen, 2012).
3. Verbal cues for stretching created the same level of tension of the stretch for each participant.
4. 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. The data from this study may only be generalized to other Division I soccer programs.
3. Fatigue may have contributed to level of effort given during study by the participants.
4. Motivation, or lack thereof, may have contributed to level of effort given during the study by the participants.

### **Delimitations**

1. Participants were all Division I women's soccer players.
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 for their sport.

### **Definitions of Terms**

Static stretching—Involves moving a limb to the end of its range of motion (ROM) and holding in the stretched position for 15–60 s (Behm & Chaouachi, 2010).

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

Dynamic stretching—Stretching that involves controlled movement through the active range of motion for a joint (Fletcher, 2010).

Backwards overhead medicine ball throw—A throw that starts with the feet hip width apart standing on the zero measurement line, and the medicine ball straight out in front of subject with the ball at shoulder level. The throw is 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 thrusts the hips vertically, swinging the arms up, releasing the ball as the arms are coming overhead around head height (Stockbrugger & Haennel, 2001).

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, and foot.

Brower Timing System—Electronic timing system used to record 30m sprint time.

Power output tests—Tests that measure power such as the BOMB throw and 30m sprint.

## CHAPTER II. LITERATURE REVIEW

The purpose of this study was to determine if the two dynamic warm-ups (medicine ball warm-up and mini-band warm-up) have a significant effect on performance in total body power output tests; and to determine if static stretching has a negative effect on performance in total body power output tests.

### **Introduction**

Static stretching has been considered an essential component of warm-ups (Young & Behm, 2002). Traditionally, a warm-up consisted of some form of submaximal aerobic exercise (ie. jogging, running, or cycling) to raise the core body temperature (Young & Behm 2002; Young, 2007). Another component of the warm-up consisted of static stretching (Behm & Chaouachi, 2010). However, this common component of a warm-up is now starting to be questioned by a substantial body of past and current research that shows static stretching decreases subsequent performance (Behm et al., 2001; Behm, Bambury, Cahill, & Power, 2004; Behm & Kibele, 2007; Fowles et al., 2000; Kokkonen et al., 1998; Power et al., 2004; Behm & Chaouchi, 2010). More recently the active warm-up has become increasingly popular and recent literature has shown increases in subsequent performance (Behm & Chaouachi, 2010; Holt & Lambourne, 2008; McMillian et al., 2006). Active warm-up, more commonly known as dynamic warm-up, involves exercise and raises both the body's core temperature and muscle temperature (Bishop, 2003b). There are primarily two main types of a dynamic warm-up: dynamic stretching and dynamic movement. Dynamic stretching involves controlled movement through the active range of motion for a joint (Fletcher, 2010). Active or dynamic warm-up involves exercise and is likely to induce greater metabolic and cardiovascular changes than static stretching (Bishop,

2003b). Much of the recent literature has shown the dynamic (active) warm-ups induce positive performance benefits (Bishop 2003a, b; Behm & Chaouachi, 2010; Holt & Lambourne, 2008; McMillian et al., 2006; Young & Behm, 2002). The primary aim of this literature review is to examine the effects of various warm-ups on power output related performance measures.

### **Static Stretching**

Static stretching involves moving a limb to its end range of motion (ROM) and holding that position for the duration of 15 seconds to 60 seconds (Young & Behm, 2002). Static stretching has been demonstrated as an effective means to increase ROM (Power et al., 2004; Behm & Chaouachi, 2010). Another benefit of static stretching is the injury prevention associated with static stretching (Behm & Chaouachi, 2010). For the better part of the last few decades, static stretching has been commonplace amongst fitness enthusiasts and athletes prior to physical activity. Much of the recent literature however, shows evidence that static stretching impairs proceeding performance (Bishop 2003a, b; Behm & Chaouachi, 2010). Research involving stretching to the point of discomfort (POD) has shown to bring about the greatest increases in ROM (Behm & Chaouachi, 2010). This research also shows that stretching to the POD results in the impairment of force (Behm et al., 2001, 2004, 2006; Fowles et al., 2000; Kokkonen et al., 1998; Young & Behm 2003) and jump height (Cornwell, Nelson, & Sidaway, 2002). Literature has certainly shown that static stretching improves ROM, however a majority of the recent literature is concurrent with static stretching impairing performance.

Although most studies have found that static stretching decreases performance in strength and power output, there are a few that have found no effect. One such study was conducted by Christensen and Nordstrom (2008), which investigated the effects of 3 different warm-ups on vertical jump performance. The study used 68 NCAA Division I athletes from North Dakota

State University that included 36 men and 32 women. The men had a mean age of 20.5 +/- 1.4 years, a mean height of 186.9 +/- 7.7 cm, and a mass of 100.7 +/- 17.7 kg. The women had a mean age of 19.8 +/- 1.2 years, height of 172.9 +/- 8.2 cm, and a mass of 67.9 +/- 9.1 kg. The study utilized a randomized, within-subject experimental repeated-measures design. The 3 types of warm-ups used in the study were a 600-m jog, a 600-m jog followed by dynamic stretching, and a 600-m jog followed by proprioceptive neuromuscular facilitation (PNF) stretching. The athletes completed the warm-ups in a counterbalanced random order. This design was used to minimize the effects of confounding variables on the outcome of the study (Christensen & Nordstrom, 2008). The study utilized the Just Jump system to measure vertical jump heights. The results of the combined data was ( $p=0.927$ ), results of the men's data ( $p=0.798$ ), and results of the women's data ( $p=0.978$ ) were found to be non-significant (Christensen & Nordstrom, 2008). The study concluded that the 3 different warm-ups did not have a significant effect on vertical jumps.

The rest of the studies in this section will show that static stretching does result in a decrease in strength and power output. For example, a study completed by Church, Wiggins, Moode, & Crist (2001), aimed to determine to what degree different warm-up routines affect performance in the vertical jump test. The study had 40 participants who were members of women's NCAA Division I tennis, rowing, volleyball, and track and field teams. The athletes had been screened by athletic trainers to rule out medical and orthopedic problems. The mean ages for the subjects were 20.3 +/- 1.6 years. The study used 3 warm-up protocols: a general warm-up, a general warm-up and static stretching, and a general warm-up and PNF stretching. The study took place on 3 nonconsecutive days. The general warm-up consisted of a body weight circuit of 10 exercises with each exercise performed for 20 seconds (Church et al., 2001). The

exercises were designed to go from less vigorous to more vigorous to warm the body up gradually (Church et al., 2001). The general warm-up took a total of 5 minutes to complete. The general warm-up and static stretching protocol consisted of the same general warm-up plus static stretches that paid attention to the hamstrings and quadriceps. The third protocol consisted of the same general warm-up from the first two treatments, plus a PNF stretch of the hamstrings and quadriceps. The PNF method used was the contract-relax agonist-contract (Church et al., 2001). After completing one of the warm-up procedures, the subjects performed three jumps on the Just Jump system; the three jumps were averaged to determine the subject's average maximum jump. The study used a 1-way repeated measures analysis of variance (ANOVA). Any significant differences by the 1-way repeated-measures ANOVA were followed by Scheffe's post hoc analysis (Church et al., 2001). The authors chose this method because of its control over type 1 errors. Statistical significance was set a  $p \leq 0.05$ . The study revealed a significant difference in decreased vertical jump performances for the PNF treatment group (Church et al., 2001). The authors concluded that PNF prior to vertical jump testing would be detrimental to performance.

A study by Young & Behm (2003) looked at the interaction between running, stretching, and practice jumps during warm-ups on explosive force production and jumping performance. The study had 16 participants, 13 male and 3 females. The subjects participated in five different warm-ups in a randomized order prior to the two jump tests. The warm-ups were control, 4 minute run, static stretch, 4 minute run and static stretch, and 4 minute run plus static stretch and practice jumps (Young & Behm, 2003). The subjects were given 2 minutes rest between the warm-ups and the jump tests. The jump tests that were performed were the drop jump and a concentric jump. These warm-ups and the jump tests were performed in random order. The authors chose these warm-up conditions to allow the specific effects of running, stretching, and

practice jumps to be observed in isolation and combination (Young & Behm, 2003). The control group consisted of walking at a comfortable pace for 3 minutes followed by bodyweight squats and heel raises. The run was not controlled but the participants were instructed to run at a pace that would induce sweating. The static stretching condition consisted of four exercises designed to stretch the ankle plantar flexors and quadriceps (Young & Behm, 2003). All stretches were taken to the “pain threshold,” and held for 30 seconds (Young & Behm, 2003). The run and stretch condition consisted of the 4 minute run and static stretching as described above. The run plus stretch, and jump include both the running and stretching protocols above with the addition of 4 warm-up practice jumps. The first practice jump was at 80% and the 3 other practice jumps were for maximal effort. The concentric jump was performed with a 10 kg bar on the shoulders performed on a modified Smith machine (Young & Behm, 2003). 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). The peak force and the maximum rate of force development (RFD) over 5msec samples during the ascending portion of the curve were recorded as explosive force production variables (Young & Behm, 2003). The subjects were required to squat and hold for 2 seconds at a 100° knee angle, measure by a goniometer, then jump for maximum height while extending the legs (Young & Behm, 2003). The drop jump was performed from a 0.30 m high box. The subjects were instructed to keep their hands on their hips and jump off the box with straight legs. Once they hit the ground they were instructed to jump for maximum height with minimum ground contact time (Young & Behm, 2003). The jump height and ground contact times were measured using a contact mat system by Swift Performance Equipment (Young & Behm, 2003). Electromyographic (EMG) data was also collected using surface EMG’s. The study using a significance level of  $p < 0.05$ , found no

significant differences between the control and run and stretch warm-ups. The run yielded significantly better scores than the run and stretch warm-up for drop jump height (3.2%), concentric jump height (3.4%), peak concentric force (2.7%), and RFD (15.4%) (Young & Behm, 2003). The run plus stretch and practice jumps warm-up produced the highest values of explosive force production with significant differences in concentric jump height (3.4%) and drop jump height/time (7.1%) (Young & Behm, 2003). Young & Behm (2003) concluded that the results indicated that sub maximum running and practice jumps had a positive effect, whereas static stretching had a negative influence on explosive force and jump performance. They also suggested that an alternative for static stretching should be considered in warm-ups prior to power activities.

## **Dynamic Warm-up**

### *Physiological changes.*

Dynamic warm-ups have become popular methods of preparation for athletes (Bishop, 2003a). Dynamic warm-up involves exercise and is likely to induce greater metabolic and cardiovascular changes than static stretching (Bishop, 2003a). The improvements in neuromuscular performance after dynamic warm-ups have been attributed to enhanced motor unit excitability (Carvalho et. al., 2012; Hamada, Sale, MacDougall, & Tarnopolsky, 2000). Other benefits include increased motor unit recruitment, decreased presynaptic inhibition, and greater central activation of the motor neuron (Carvalho et al., 2012; Aagaard, Simonsen, Andersen, Magnusson, & Dyhre-Poulsen, 2002). One of the benefits of dynamic warm-ups is that they prepare the muscles and joints in a more specific manner since the body is going to go through motions which will likely be repeated in the workout or sport. Dynamic warm-ups increase the muscular flexibility through the neuromuscular system and decrease reflexive

muscle contractions by stimulating the Golgi tendon organs (Bishop, 2003b). Bishop (2003b) adds that dynamic warm-ups improve short-term performance because most factors are related to temperature and include decreased stiffness of the muscles and joints (Behm & Chaouachi, 2010).

Dynamic stretching is a form of stretching that is beneficial for pushing the muscle into an extended range of motion that does not exceed one's static-passive stretching ability (Bishop, 2003a, b; Behm & Chaouachi, 2010; Fletcher, 2010). This form of stretching, which encompasses progressive and continuous movement prepares the body for physical exertion (Bishop, 2003a). Dynamic stretching has been reported to improve power and jump performance, or have no adverse effects (Carvalho et al, 2012; Church, Wiggins, Moode, & Crist, 2001; Dalrymple, Davis, Dwyer, & Moir, 2010). The benefits of dynamic stretching are illustrated by understanding the neuromuscular system of the muscle complex. One benefit of dynamic stretching activities is that they aide in short-term flexibility gains through stimulation of the Golgi tendon organs (Bishop, 2003b).

### ***Metabolic adaptations.***

In today's sport culture, the role the warm-up plays is critical. It is important to understand the rationale behind the warm-up and the purpose of the warm-up. The goal of a warm-up is to prepare athletes physically for exercise. Warm-ups are designed to increase muscle temperature, core temperature, and blood flow (Enoka, 2002; Jeffreys, n.d). These effects can have a positive influence on the following: faster muscle contraction and relaxation of both agonist and antagonist muscles (Hoffman, 2002), improvements in rate of force development and reaction time (Asmussen, bonde-Peterson, & Jorgenson, 1976), increased output of muscle strength and power (Enoka, 2002), improved oxygen delivery due to the Bohr

effect where higher temperatures facilitate oxygen release from hemoglobin and myoglobin (McArdle, Katch, & Katch, 2001), and increased blood flow to active muscles (McArdle et al., 2001). Bennett (1984) found that the speed of muscular contraction and rate of force application are highly dependent on temperature. Previous research has suggested that an active warm-up may increase neural stimulation of fast-twitch A motor units (Burnley, Doust, Carter, & Jones, 2001; Koppo & Bouckaert, 2001). Another benefit of the warm-up is the reduced risk of injury which some evidence suggests a positive effect (Fradkin, Gabbe, & Cameron, 2006; Shrier, 2000).

A study performed by Brown, Hughes, & Tong (2008) investigated the effect of previous warming on high-intensity intermittent running. The study used 10 male semiprofessional soccer players with a mean age of 22.0 +/- 1.0 years and height of 1.80 +/- 0.06 meters. The subjects visited the laboratory 5 times during a 2-week testing period with a minimum of 24 hours between each test. The subjects completed a repeated sprint test (10 x 6-second sprints with 34 seconds recovery between sprints) preceded by an active warm-up, passive warm-up, or no warm-up (control) (Brown et al., 2008). The active warm-up consisted of 10 minutes of running with a Vo<sub>2</sub>max of 70% and a mean core temperature of 37.8 +/- 0.2°C. The passive warm-up was a hot water submersion with a mean core temperature of 40.1 +/- 0.2°C. All warm-up conditions were followed by a 10-minute rest period. Core temperature was higher before exercise in the passive trial compared to both the active and control trials. Heart rate was greater in the active trial ( $p < 0.05$ ) compared to the passive and control trial. The authors had 3 main findings to the study. The first was that there was no difference in high-intensity intermittent running speed when preceded by either an active or passive warm-up. The second, there were no significant differences in measures of performance fatigue between all conditions. The third is

that both active and passive warm-ups significantly improved repeated sprint running speed compared to control (Brown et al., 2008). This study shows that increased core temperature and muscle temperature increased the subjects speed or ability to generate power. This is consistent with other research that increased core and muscle temperature increases power output.

***Performance benefits.***

To further examine the debate between static and dynamic stretching, one group of researchers' decided to study the effects of dynamic versus static stretching warm-ups on power and agility performance assessed by a T-shuttle run, underhand medicine ball throw, and 5-step jump (McMillian et. al., 2006). The 5-step jump was chosen as a measure of functional leg power, the underhand medicine ball toss for measure of total body power, and the T-shuttle drill primarily as a measure of agility. The dynamic warm-ups consisted of warm-ups that closely mimicked the power and agility requirements of many sports as well as the exercises performed in the testing protocol. One could assume the authors focused on dynamic medicine ball warm-ups, and dynamic agility warm-ups (McMillian et al., 2006). However, the researchers did not explain the dynamic warm-ups protocol. Nevertheless, the researchers found that the dynamic stretching group had better performance results for all three tests (McMillian et al., 2006). The results of this study are consistent with Bishops' (2003b) review of the literature, indicating that an active warm-up of moderate intensity is likely to significantly improve short-term performance as long as fatigue is not induced (Bishop, 2003b; McMillian et al., 2006).

The following research included a more diverse set of outcome measures: including peak torque of the quadriceps and hamstrings, medicine ball throw, 300-yd shuttle, pull-ups, push-ups, sit-ups, broad jump, 600-m run, sit-and-reach test, and trunk extension test (Herman & Smith, 2008). The purpose of this study was to determine whether a dynamic-stretching warm-up

(DWU) intervention performed daily over 4 weeks positively influenced power, speed, agility, endurance, flexibility, and strength performance measures when compared to a static-stretching warm-up (SWU) intervention. Researchers used 24 male NCAA Division I collegiate wrestlers. The wrestlers were randomly assigned to complete either a 4-week treatment condition (DWU) (n = 11) or an active control condition (SWU) (n = 13) prior to their daily preseason practices. Performance measures were then conducted before and after the 4-week experimental period. The researchers found that the DWU intervention had several performance improvements, including increases in quadriceps peak torque (11%), broad jump (4%), medicine ball throw (4%), sit-ups (11%), and push-ups (3%) (Herman & Smith, 2008). In addition, there was also a decrease in the average time to completion of the 300-yd shuttle (-2%) and the 600-m run (-2.4%), which was suggestive of enhanced muscular strength, endurance, agility, and anaerobic capacity in the DWU group (Herman & Smith, 2008). The SWU group had no improvements in any of the outcome measures.

### **Performance Power Tests**

#### ***Countermovement jump performance.***

Consideration of sports-specific dynamic warm-ups facilitates the adoption of different kinds of dynamic warm-ups. For example, Burkett, Phillips, and Ziuraitis (2005) tested four different types of warm-ups on vertical jump in college-age males. Two of the warm-ups were dynamic and the other two consisted of static stretching warm-up and no warm-up as a control. One of the dynamic warm-ups was a submaximal jump warm-up and the other was a weighted jump warm-up with an external load. All participants completed the four different warm-up protocols and were tested on the vertical jump test after each warm-up. The researcher's results revealed that the warm-up with the greatest effect on jump performance was the dynamic warm-

up which involved the overload principal (weighted jump warm-up) (Burkett et al., 2005). An external load can be easily understood as some weight or force, external to the muscle and the immediate part of the body it operates. The common element to all possible examples of external loads is what the person intends to move or support. This motion is similar to the movement involved in the workout or sport. In the case of Burkett et al.'s (2005) study, the external load during the weighted warm-up proved to be most beneficial in jump performance.

Another study that was conducted by Holt and Lambourne (2008) tested 63 National Collegiate Athletic Association (NCAA) Division I male football players' countermovement jump height following one of four warm-up conditions. The four warm-up conditions tested were: warm-up only (5-10 minutes of submaximal cardiovascular activity), warm-up plus static stretching, warm-up plus dynamic stretching, and warm-up plus dynamic flexibility (Holt & Lambourne, 2008). The study concluded that three of the four warm-up conditions were statistically significant for improving countermovement jump performance (Holt & Lambourne 2008). The condition that did not improve performance was the warm-up plus static stretching. Holt and Lambourne (2008) concluded that these results were consistent with recent literature and supported their hypothesis that static stretching would not improve jump performance.

Another study by Frantz and Ruiz (2011) examined collegiate baseball players' countermovement vertical jump and standing long jump after completing one of three warm-up routines. The three warm-up routines included a control, a static stretching routine, and a dynamic warm-up routine. The researchers found that there were significant improvements in both vertical jump and standing long jump with the control and dynamic warm-up groups (Frantz & Ruiz, 2011). The author's stated that these results are consistent with previous findings in literature (Frantz & Ruiz, 2011).

In a study conducted by Carvalho et al. (2012), the researchers examined the acute effects of active, passive, and dynamic stretching warm-ups on vertical jump (VJ) performance. The study had 16 participants that were young tennis players (age 14.5 +/- 2.8 years). The study used four experimental conditions: (a) control condition (CC) – VJ without stretching exercises; (b) passive stretching condition (PSC) – VJ performed after passive static stretching; (c) active stretching condition (ASC) – VJ performed after static stretching; and (d) dynamic stretching condition (DC) – VJ performed after dynamic stretching (Carvalho et. al, 2012). These warm-up protocols were completed after five minutes of running with a standardized hear rate of approximately 140 beats per minute and performing 10 jumps (5 squat jumps and 5 countermovement jumps) that aimed to reproduce to tests, but with lower intensity (Carvalho et. al, 2012). The study used a one-way repeated measures analysis of variance and concluded that there were statistically significant increases in jump performance with the ASC and DC when compared to the PSC (Carvalho et. al, 2012). The researchers' concluded that dynamic stretching interventions appeared to be useful as part of a warm-up for athletes.

### ***Sprint performance.***

A study by Fletcher & Jones (2004) aimed to determine the effect of different static and dynamic stretch protocols on 20m sprint performance. The researchers utilized 97 male rugby union players which were randomly assigned to four groups; (a) passive static stretch (PSS) (n=28), (b) active dynamic stretch (ADS) (n=22), (c) active static stretch (ASS) (n=24) and (d) static dynamic stretch (SDS) (n=23). The PSS group carried out passive stretches (slowly applied stretch torque to a muscle, maintaining the muscle in a lengthened position) of the lower body for 20 seconds to the point of discomfort (Fletcher & Jones, 2004). The ADS group carried out a series of lower body dynamic stretches (controlled movement through the active range of

motion for each joint) at a jogging pace (Fletcher & Jones, 2004). The exercises used in the ADS group were designed to stretch the same muscles as the PSS group. Each stretch exercise was performed for 20 repetitions per leg. The ASST performed active stretches (an active contraction of the agonist muscle to its full inner range, stretching the antagonist's outer range) (Fletcher & Jones, 2004). Stretches were the same as those performed by the PSS group and held for 20 seconds per group. The SDS group performed the same movements as the ADS group but in a stationary position for 20 repetitions per leg. All groups performed a standard 10-min jog warm-up, followed by two 20m sprints. The subjects then repeated another 20m sprint after subjects performed the two different stretch protocols. After the experimental sessions were complete the researchers found that the PSS and ASS groups had a significant increase in sprint time with a mean of  $3.27 \pm 0.17$  and  $3.29 \pm 0.2$  respectively with an alpha of  $p < 0.05$ , while the ADS group had a significant decrease in sprint time with a mean  $3.18 \pm 0.18$ , and an alpha of  $p < 0.05$ . The decrease in sprint time, observed in the SDS group, was found to be non-significant with a mean time of  $3.22 \pm 0.21$ , and an alpha of  $p > 0.05$  (Fletcher & Jones, 2004). The results showed that the ADS group lowered their sprint times significantly, while the PSS and ASS groups increased their sprint times. The researchers determined that the decrease in performance for the two static stretch groups was attributed to an increase in the musculotendinous units' (MTU) compliance, leading to a decrease in the MTU ability to store elastic energy in its eccentric phase (Fletcher & Jones, 2004). However, the improvements in the ADS group were not as clear. The possible rehearsal of the specific movement patterns may have attributed to the improvements, which may help increase coordination of subsequent movement. It is known that dynamic warm-ups also present many other benefits which may have also played a role; such as

core temperature increase, maximize active ranges of motion, and increase oxygen uptake (Bishop, 2003b).

Another study tested short sprint type activities and took a unique approach of analyzing the effect of different warm-ups while also utilizing a weighted vest (Faigenbaum et al., 2006). In this study, the researchers examined the acute effects of four warm-up protocols with and without a weighted vest on vertical jump, long jump, seated medicine ball toss, and 10-yard sprint in female high school athletes. Eighteen healthy high school female athletes (age =  $15.3 \pm 1.2$  years, height =  $166.3 \pm 9.1$  cm, mass =  $61.6 \pm 10.4$  kg) performed four randomly ordered warm-up protocols after 5 min of jogging: Five static stretches ( $2 \pm 30$  seconds) (SS), nine moderate-intensity to high-intensity dynamic exercises (DY), the same nine dynamic exercises performed with a vest weighted with 2% of body mass (DY2), and the same nine dynamic exercises performed with a vest weighted with 6% of body mass (DY6). The researchers found that vertical jump performance was significantly greater after DY (mean  $41.3 \pm 5.4$  cm) and DY2 (mean  $42.1 \pm 5.2$  cm) compared with SS (mean  $37.1 \pm 5.1$  cm), and long jump performance was significantly greater after DY2 (mean  $180.5 \pm 20.3$  cm) compared with SS (mean  $160.4 \pm 20.8$  cm) ( $p \leq .05$ ) (Faigenbaum et al., 2006). No significant differences between trials were observed for the seated medicine ball toss or 10-yard sprint. However, it must be noted that the dynamic warm-ups that the researchers employed were specific to the lower body extremities. A 10-yard sprint and medicine ball throw rely heavily on the upper body extremities. This leads the reader to believe that the warm-up protocols were not specific enough to the upper body and that any performance improvements that may have been observed otherwise are not accounted for in this article.

Based on current research, there is substantial research to support the assertion that static stretching has an acute impairment on performance. Subsequently, dynamic stretching and dynamic warm-ups cause improvements on performance. More research is needed to explore different types of dynamic warm-ups.

***Backwards overhead medicine ball (BOMB) throw.***

In sport, the ability to generate and transfer power is critical to success. Evaluating these expressions of power can aid in the improvement of athlete's ability to generate more power (Stockbrugger & Haennel, 2003). A number of field tests have been used to provide feedback to athletes in regards to performance; these tests include the countermovement vertical jump and the standing long jump for lower body strength and power (Duncan et al., 2005; Stockbrugger & Haennel, 2001). The BOMB throw provides a field-based testing modality for the assessment of total body explosive power (Duncan et al., 2005). The BOMB throw is a throw that starts with the feet hip width apart standing on the zero measurement line, and the medicine ball straight out in front of subject with the ball at shoulder level. The throw is 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 thrusts the hips vertically, swinging the arms up, releasing the ball as the arms are coming overhead around head height (Stockbrugger & Haennel, 2001).

In a study conducted by Clayton et al., (2011) the authors studied the relationships between isokinetic core strength and athletic performance test in collegiate male baseball players. Twenty-nine male collegiate baseball players (20.4 +/- 1.6 yrs) from the University of Dayton (OH) were used in this study. All the subjects participated in five data collection sessions. Two of these sessions were familiarization meetings. The tests included a body

composition test, vertical jump, hang clean, BOMB throw, and McGill Plank battery (Clayton et al., 2011). To maximize performance, the authors ordered the tests as suggest by the National Strength and Conditioning Association (NSCA): vertical jump, hang clean, BOMB throw, and McGill Plank battery. The vertical jump was measured using a Vertec measuring instrument. The hang clean was tested by performing a one rep max. The BOMB throw was measured to the nearest inch, starting from a zero measurement line on a laid out tape measure. The McGill Plank battery was conducted to test subjects' muscular endurance and strength of the core. Isokinetic core strength was assessed using a Cybex isokinetic equipment that measured torque at different speeds (Clayton et al., 2011). The authors used Statistical Package for Social Science (SPSS) Version 17.0) software to analyze their data. Statistically significant correlations were found ( $p \leq 0.05$ ). The authors found that the BOMB throw consistently produced significant correlations with all measures of isokinetic core strength. The authors go on to conclude that performance on the BOMB throw yielded statistically significant relationships with anthropometric measures of bodyweight, BMI, and lean weight as well as isokinetic strength (Clayton et al., 2011). They summarized that the data strongly suggests that the BOMB throw may be used as a reliable predictor of core strength.

Another study looked at the relationship of the BOMB throw with Olympic weightlifting performances. The purpose of this study was to determine the relationship between the BOMB throw and a maximal snatch and clean and jerk (Palozola, Koch, & Mayhew, 2010). The study used twelve collegiate Olympic weightlifters (8 men, 4 women, mass =  $75.3 \pm 15.4$  kg, age =  $21 \pm 1$  yr). The subjects completed six maximal throws with a 3.63 kg medicine ball with 1 minute rest between throws. The best results was recorded and used for data analysis. Three to five days after completing their BOMB throws, the subjects competed in a sanctioned weightlifting meet.

The subjects maximum snatch and clean and jerk weights from the meet were correlated with their best BOMB throw result. Intraclass correlation coefficient across all 6 trial (ICC = 0.99) indicated a high degree of reliability (Palozola et al., 2010). The best BOMB throw was significantly correlated ( $p < 0.01$ ) with snatch ( $r = 0.85$ ) and clean and jerk ( $r = 0.90$ ). Body mass was significantly correlated with BOMB throw ( $r = 0.78$ ), snatch ( $r = 0.83$ ), and clean and jerk ( $r = 0.82$ ). The correlation of BOMB throw with Sinclair-adjusted snatch ( $r = 0.81$ ) and clean and jerk ( $r = 0.86$ ) were significant (Palozola et al., 2010). The authors concluded that the strong correlation between the BOMB throw and the snatch and clean and jerk may be dependent on body mass. They go on to imply that the BOMB throw distance may be strongly dependent on body mass but may reflect a unique aspect of total body power (Palozola et al., 2010). Further research is warranted to determine if an adjustment scaling technique is required to facilitate its use on a wide variety of athletes.

The purpose of this next study was to evaluate the validity and reliability of a BOMB throw test to assess explosive power (Stockbrugger & Haennel, 2001). The study used 20 competitive sand volleyball players (10 male, 10 female). The population had an age range of 16-30 with a mean age  $22.8 \pm 3.7$  years and a mean body mass of  $75.7 \pm 14.8$  kg. The subjects performed the BOMB throw and the countermovement vertical jump. The authors standardized for body weight using a power index that was calculated for the countermovement jump using the Lewis formula (Stockbrugger & Haennel, 2001). Validity was assessed using the best score for both the BOMB throw and countermovement vertical jump from each session. The subjects attended two sessions in which three attempts of each test were completed. An intraclass correlation coefficient was used to examine the test-retest reliability, and Pearson product correlations were used to establish the relationship between the BOMB throw distance,

vertical jump height, and power index from the vertical jump, and body weight (Stockbrugger & Haennel, 2001.) Paired t-tests were used to determine if there were any significant differences between the test and retest. The Pearson product correlations were also used to evaluate the variability of scores among the groups. A significance level of  $p \leq 0.01$  was chosen for all tests. The authors found that there was a strong correlation between the distance of the BOMB throw and the power index for the countermovement vertical jump ( $r=0.906$ ,  $p<0.01$ ). The BOMB throw had a test-retest reliability of 0.996 ( $p<0.01$ ). The findings of Stockbrugger & Haennel (2001) suggest that the BOMB throw is a valid and reliable test for assessing explosive power for a total body movement pattern.

## CHAPTER III. METHODS

### **Experimental Design**

An experimental repeated measures design was used to examine the effects of four different warm-ups (control, static stretching, dynamic medicine ball, and dynamic mini-band) on total body power output tests. A modified incomplete counterbalanced design for the warm-up conditions and testing was used. The independent variables in this study are the four warm-up conditions. This study was part of a larger study that also involves testing other measures of power and agility. However, this study will focus on the backwards overhead medicine ball throw (BOMB Throw) and the 10 and 20m sprint, which are the dependent variables. All participants performed one of the four warm-up conditions each day followed by the BOMB Throw and 10 and 20m sprint. The BOMB throw was measured by using a tape measure (Martin 165ft/50m tape measure) taped to the ground and the throw recorded in meters. The 10 and 20m sprint were measured using the Brower Speed Trap II Timing System (Brower Timing Systems, Draper, Utah) and recorded in seconds.

### **Subjects**

A convenience sample of 24 Division I women's soccer players participated, however 5 subjects dropped out due to sustaining injuries from a weekend soccer tournament. Subjects who were healthy and who did not have a history of serious knee injuries were included. Those athletes who have had a significant knee injury in the past year (ACL/MCL tear) were excluded from the study. Individuals who were sick within 48 hours of testing (flu like symptoms) as notified by athletic trainer or doctor were excluded from the study. This research proposal was approved by the North Dakota State University Institutional Review Board.

## **Procedures**

The study began with a meeting describing the study, gaining informed consent, and providing information for testing dates and times. The subjects were randomized into four groups for the study. Days 2-5 consisted of testing, utilizing a modified incomplete counter-balancing scheme. Testing took place over the course of four evening sessions at 7:00 pm and 7:30 pm at the North Dakota State University's Shelly Ellig Indoor Track Facility. The Shelly Ellig Indoor track consists of a large infield including the high jump, long jump, and throwing circle and sectors, with a 200-meter track around its perimeter. All testing results were recorded on data sheets and later put into an excel spreadsheet.

The subjects came in for testing in two flights. Flight I consisted of groups 1 and 2, and flight II consisted of groups 3 and 4. This remained consistent throughout the duration of the study to keep the testing times the same throughout the study. Each group performed their warm-up condition (see Table 1 in Chapter 4) for the day followed by the testing protocol. The warm-ups were conducted utilizing a modified incomplete counter-balanced scheme.

The dynamic warm-ups each involved seven movements. The static stretching condition involved eight stretches. See Table 2 in Chapter 4 for a list of the specific warm-up exercises.

Because this study was part of a larger study being conducted by several researchers, there were three testing stations set up to accomplish all the tests involved in the larger study. At Testing Station II, participants completed the BOMB Throw testing performance and the 10 and 20 m sprint performance. See Table 3 in Chapter 4 for the details at each testing station. The control group started their five minute warm-up jog once the other group had completed their five minute jog and begun their assigned warm-up condition to time up the groups so they all started testing at the same time.

Once the groups completed their warm-up they had a 2 minute break to get a drink of water and proceed to their assigned test. After completion of their first test, they had another 2 minute break and rotated to the next test. This procedure took place for a third and fourth time to complete all of the tests involved in the larger study (see Table 4 in Chapter 4).

### **Instrumentation**

Testing Station II utilized the Martin 165ft/50m tape measure taped to the ground. Subjects threw a 4 kilogram (kg) medicine ball backwards overhead. The throw starts with the feet hip width apart standing on the zero measurement line, and the medicine ball straight out in front of subject with ball at shoulder level. The throw is 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 thrusts 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 ball landed alongside of the measuring tape. The BOMB Throw has been shown to be a valid and reliable test of total body power as found in current research (Stockbrugger & Haennel, 2001; Duncan & Hankey, 2010).

The 10 and 20 m sprint was measured in seconds utilizing the Brower Speed Trap 2 Timing System (Brower Timing Systems, Draper, UT). The subjects began on the start line in a 2 point runner's stance. The timing was started by the researcher on the subjects' first movement. The timing was stopped when the subject passed through the electronic gates at the 20 m line. The 10m split time was taken when the subject passed through the first set of timing gates. The Brower Timing System has been deemed a valid and reliable test as confirmed in current research (Shalfawi et al., 2012).

## **Statistical Analysis**

SPSS version 22 was used to analyze the data. The best performance for each test was used for analysis with an alpha level of  $<0.05$ . The study used three separate univariate repeated measure analysis of variance (ANOVA), one for each testing protocol. If the ANOVA was found to be significant, follow-up analyses using Bonferroni corrected pair-wise comparisons were conducted.

CHAPTER IV. MANUSCRIPT FOR PUBLICATION: THE EFFECTS OF TWO TYPES OF  
DIFFERENT DYNAMIC WARM-UPS AND STATIC STRETCHING ON TOTAL BODY  
POWER AND SPEED

**Abstract**

Static stretching has been shown to decrease muscle performance (Shrier, 2004). More recently, dynamic warm-ups have been found to induce positive performance benefits (Bishop, 2003a; Behm & Chaouachi, 2010; Holt & Lambourne, 2008; McMillian, et al., 2006; Yeong & Behm, 2002). A proper warm-up is crucial to maximizing performance for testing and competition. The purpose of this study was to determine if dynamic warm-ups have a significant effect on performance in total body power and speed; and to determine if static stretching has a negative effect on performance in total body power and speed. An experimental repeated measures design was used. A convenience sample of 24 Division I women's soccer players participated, however 5 subjects dropped out due to sustaining injuries from a weekend soccer tournament. Subjects were randomized into four groups for the study. Testing utilized a modified incomplete count-balance scheme. Subjects came in for testing in two flights. Flight I consisted of groups 1 and 2, and flight II consisted of groups 3 and 4. Each group performed their warm-up condition for the day followed by the testing protocol. The four warm-ups included the control, mini-band warm-up, medicine ball warm-up, and static stretching warm-up. The tests were the BOMB throw and a 20 m sprint with a 10 m split time. The study used three separate univariate repeated measure analysis of variance with follow-up pairwise comparisons for significant ANOVAs. The ANOVAs for the BOMB throw ( $F=0.87$ ,  $p=0.49$ ) and 20 m sprint ( $F=1.65$ ,  $p=0.25$ ) were not significant. The ANOVA for the 10 m split was significant ( $F=4.04$ ,  $p=0.045$ ). Paired t-test results showed that there was a significant difference between the mini-

band and control conditions ( $t=2.83$ ,  $p=0.02$ ) and a significant difference between the medicine ball and control conditions ( $t=2.78$ ,  $p=0.02$ ). In both cases the control was found to result in the best performance.

## **Introduction**

A proper warm-up has long been considered necessary for maximizing athletic performance (Behm & Chaouachi, 2010). Warm-ups typically consist of submaximal aerobic activity, stretching, and sport-specific activity (Behm & Chaouachi, 2010). The goal of a warm-up is to minimize the risk of injury and enhance performance. Throughout the years, static stretching has been shown to decrease muscle performance (Shrier, 2004). More recently dynamic warm-up has become increasingly popular and recent literature has shown increases in subsequent performance (Behm & Chaouachi, 2010; Holt & Lambourne, 2008; McMillian, et al., 2006).

The traditional warm-up consisted of a submaximal aerobic component (i.e. running or cycling) whose goal was to raise core temperature (Behm & Chaouachi, 2010; Young, 2007; Young & Behm, 2002). Increased body temperature has been found to increase muscle activity and nerve conduction (Behm & Chaouachi, 2010; Young, 2007). The second part of a traditional warm-up was a bout of static stretching (Young, 2007; Young & Behm, 2002) that involved moving a limb to its end range of motion and holding that position for 15-60 seconds (Behm & Chaouachi, 2010; Young, 2007; Young & Behm, 2002). The third component was a bout of dynamic movements similar to the sport or event for which they were preparing (Young & Behm, 2002).

A more optimal warm-up today consists of submaximal intensity aerobic activity, followed by dynamic stretching, and finishing with sport specific dynamic activities (Behm &

Chaouachi, 2010). Static stretching still plays an important role for health related benefits associated with flexibility and is still performed after the activity for those reasons. Static stretching should normally not proceed strength, high speed, explosive or reactive activities (Behm & Chaouachi, 2010).

The purpose of this study was to determine if dynamic warm-ups have a significant effect on performance in total body power and speed; and to determine if static stretching has a negative effect on performance in total body power and speed. We hypothesized that the dynamic warm-up conditions would have a positive impact on testing measures. Coincidentally, we hypothesized that the static stretching and a jogging only warm-up will have no or negative impacts on testing.

## **Methods**

### ***Experimental approach to the problem.***

An experimental repeated measures design was used in this study to examine the effects of four different warm-ups (control, static stretching, dynamic medicine ball, and dynamic mini-band) on total body power output and speed. A modified incomplete counterbalanced design was used for the warm-up conditions and dependent variable testing. The independent variables in this study were the four warm-up conditions. This study was part of a larger study that also involved testing other measures of power and agility. However, this study will focus on the backwards overhead medicine ball throw (BOMB Throw) and a 20 m sprint with a 10 m split, which are the dependent variables. All participants performed one of the four warm-up conditions each day followed by the BOMB Throw and 20 m sprint in random order. The BOMB throw was measured by using a Martin 165ft/50m tape measure, which was taped to the floor. All the throws were recorded in meters. The 20 m sprint and 10 m split times were

measured in seconds using the Brower Speed Trap II Timing System (Brower Timing Systems, Draper, Utah).

***Subjects.***

A convenience sample of 24 Division I women's soccer players participated, however 5 subjects dropped out due to sustaining injuries from a weekend soccer tournament. Subjects who were healthy and did not have a history of serious knee injuries were included. Those subjects who had a significant knee injury with-in the past year (ACL/MCL tear) were excluded from the study. The research was approved by the North Dakota State University Institutional Review Board and all participants gave informed consent prior to completing the study.

***Procedures.***

The subjects were randomly assigned into four groups. On day 1, the scope of the study was explained and informed consent forms were given to the participants. Days 2-5 of the study consisted of testing, utilizing a modified incomplete counter-balancing scheme. Testing took place over the course of four evening sessions at 7:00 pm and 7:30 pm at the North Dakota State University's Shelly Ellig Indoor Track Facility. The Shelly Ellig Indoor track consists of a large infield including the high jump, long jump, and throwing circle and sectors, with a 200-meter track around its perimeter. All testing results were recorded on data sheets and later put into an excel spreadsheet.

The subjects came in for testing in two flights. Flight I consisted of groups 1 and 2, flight II consisted of groups 3 and 4. This procedure remained consistent throughout the duration of the study in order to keep the testing times the same for each group throughout the study. Each group performed their warm-up condition (see Table 1) for the day followed by the testing protocol. The warm-ups were conducted utilizing a modified incomplete counter-balanced scheme.

Table 1

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

Group	Day 2	Day 3	Day 4	Day 5
1	Mini-Bands	Medicine Ball	Static Stretching	Control
2	Medicine Ball	Mini-Band	Control	Static Stretching
3	Static Stretching	Control	Medicine Ball	Mini-Bands
4	Control	Static Stretching	Mini-Bands	Medicine Ball

The dynamic warm-ups involved seven movements. The static stretching condition involved eight stretches. See Table 2 for a list of the specific warm-up exercises.

Table 2

*The activities completed for each warm-up condition*

Control Warm-Up	Mini-Band Warm-Up	Medicine Ball Warm-Up	Static Stretching Warm-Up
5 minute jog	Band Above Knees Bodyweight squats	Counterbalanced squat  Overhead chops	Performed on both right and left sides  Groin
	Band Below Knees Monster walks Over-stride slide	Forward lunge with twist over knee  Floor pass	Hip flexor Lunge  Lying glute
	Band Around Ankles Straight leg walks forward & backwards Straight leg walks lateral	Counterbalance romanian deadlift (RDL)  Side slams	Lying quad  Seated hamstring  Standing
	Band Around Feet Hip flexion Hip rotation	Reverse lunge with bend over knee	Gastrocnemius  Arm across body  Arm behind head

Because this study was part of a larger study being conducted by several researchers, there were 3 testing stations set up to accomplish all the tests involved in the larger study. See

Table 3 for details about each testing station At Testing Station II. Participants for this part of the study completed the BOMB Throw testing and the 20 m Sprint. Under the control condition the group started the five minute warm-up jog once the other group had completed the five minute jog. This procedure was followed so that they would be finish their jog at approximately the same time as the other groups completed the other warm-ups. This assured that the groups would all started the testing at the same time.

Table 3

*Testing Stations used in the overall study*

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

When the groups completed their warm-up they had a 2 minute break to get a drink of water and proceed to their assigned test. After completing the first test, they had another 2 minute break to get a drink and rotate to the next test. This same procedure took place for a third and fourth time so that all of the tests involved in the larger study were completed (see Table 4).

Table 4

*Test procedures*

Group	Day 2	Day 3	Day 4	Day 5
1	BOMBT, 20 M, VJ, T-Test	20M, BOMBT, T- Test, VJ	VJ, T-Test, BOMBT, 20M	T-Test, VJ, 20M, BOMBT
2	20 M, BOMBT, T- Test, VJ	BOMBT, VJ, 20 M, T-Test	T-Test, 20M, VJ, BOMBT	VJ, T-Test, BOMBT, 20 M
3	VJ, T-Test, BOMBT, 20 M	T-Test, 20M, VJ, BOMBT	20 M, BOMBT, T- Test, VJ	BOMBT, 20 M, VJ, T-Test
4	T-Test, VJ, 20M, BOMBT	VJ, T-Test, BOMBT, 20 M	BOMBT, VJ, 20 M, T-Test	20M, BOMBT, T- Test, VJ

***Instrumentation.***

The BOMB throw involved the subjects throwing a 4 kilogram (kg) medicine ball backwards overhead. The throw starts with the feet hip width apart standing on the zero measurement line, with the medicine ball straight out in front of subject at shoulder level. The throw is 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 thrusts the hips vertically, swinging the arms up, releasing the ball as the arms are coming overhead around head height (Stockbrugger & Haennel, 2001). The throws were measured from the side of the ball towards the subject as it landed. The BOMB Throw has been shown to be a valid and reliable test of total body power as found in current research (Duncan & Hankey, 2010; Stockbrugger & Haennel, 2001).

## Statistical Analysis

SPSS version 22 was used to analyze the data. The best performance for each test was used for statistical analysis with an alpha level of  $<0.05$ . The study used three separate univariate repeated measure analysis of variance (ANOVA), one for each dependent variable.

## Results

The ANOVA for the BOMB throw was not significant ( $F=0.87$ ,  $p=0.49$ ), In order from the worst to best performances and average: mini-band ( $7.09\pm.97m$ ), medicine ball ( $7.11\pm1.29m$ ), control ( $7.26\pm1.0m$ ), and static stretching ( $7.37\pm1.13m$ ). For the 10 meter split the ANOVA was significant ( $F=4.04$ ,  $p=0.045$ ). Paired sample t-test results showed that there was a significant difference between the mini-band control conditions ( $t=2.73$ ,  $p=0.02$ ). There was also a significant difference between the medicine ball and control conditions ( $t=2.78$ ,  $p=0.02$ ). In both cases the control warm-up was found to result in the best performance. None of the rest of the comparisons were significant. Ordered from worst to best performance and average: mini-band ( $2.12\pm.10s$ ), medicine ball ( $2.09\pm.08s$ ), static stretch ( $2.08\pm.08s$ ), and control ( $2.04\pm.08s$ ). The ANOVA was not significant ( $F=1.65$ ,  $p=0.25$ ) for the 20 meter sprint. Ordered from worst to best: mini-band ( $3.56\pm.14s$ ), static stretching ( $3.54\pm.11s$ ), medicine ball ( $3.53\pm.13s$ ), and control ( $3.5\pm.11s$ ).

## Discussion

Based on the results of other similar studies, we hypothesized that static stretching and the control condition would result in the lowest performance. However, we found that the mini-band warm-up resulted in the worst performance in the 10m sprint times and the control condition resulted in the best performance. This is especially interesting as jogging most closely resembles the biomechanics and motions of sprinting. This information may be particularly useful when designing warmups prior to speed and conditioning sessions, practice, and competition where running is the most dominant form of movement.

Our results do not agree with Fletcher and Jones' (2004) results, where they examined the effects of static and dynamic stretching on the 20m sprint. They found that static stretching resulted in a significant increase and dynamic stretching led to a significant decrease in 20m sprint times. Our results also contradict McMillian et al. (2006), who found that a dynamic stretching group had better performance in an underhand medicine ball throw than a static stretching group. The results of the McMillian et al. (2006) study are consistent with Bishops' (2003b) review of the literature, indicating that an active warm-up of moderate intensity is likely to significantly improve short-term performance as long as fatigue is not induced (Bishop, 2003b; McMillian et al., 2006). Our results did agree with a study by Faigenbaum et al. (2006). They found no significant differences in a seated medicine ball throw or 10 yard sprint times after completing static stretching and three dynamic warm-ups of varying intensity using a weighted vest.

The athletes in our study had completed sport related practice earlier in the days we did testing and they had a grueling soccer tournament during one of the weekends between our testing days. The team, which consisted of 24 girls, was split into two separate teams of ten to compete in a 10vs10 weekend tournament. By splitting the team into two teams, all the girls participated in multiple full matches which is more time than they would typically see if the team wasn't split. These factors could have resulted in fatigue in the subjects on top of the fatigue from completing the study, which may have affected our results.

Soccer is a sport of both endurance, a match is ninety minutes long with two forty-five minute halves, and repeated sprint ability. On average, and depending on position, an athlete may cover anywhere from 4-8 miles per match. Soccer athletes also must be able to sprint after a ball,

or as a defender to guard other players, many times throughout the course of a match. This makes soccer a game of endurance as well as speed.

### **Practical Applications**

Proper warm-up prior to workouts, practice, and competition is vitally important in keeping subjects healthy and injury free. The information in this study can be used in developing appropriate modes of warm-ups depending on the activity. This information can also be used to determine if the desired warm-up will have an effect on the outcome of the activity. Based on the results of this study it may be prudent to decrease warm-ups if the athletes are fatigued from previous competitions, sports practice, and work-outs before conducting any power based testing.

Fatigue is a crucial factor to accommodate for in designing warm-ups and workouts. It would not be in an athlete's best interest to do a high intensity warm up in an overly fatigued state as this puts them at high risk for injury. At the same time, athletes who are fatigued need to be appropriately warmed up (i.e. increased core temperature, increased neural drive, muscles loosened up).

If athletes are fatigued, it could be in the coach's best interest to allow them to "choose" their warm up as they know their bodies the best. This may include giving the athletes or clients a set duration of time to warm up as they see fit using what modalities they prefer (i.e. bike, elliptical, foam roll, medicine ball, mini-bands, dynamic stretching, static stretching, rowing machine, barbell, etc.). Or you may have multiple warm up routines that they can choose from. There are many ways to get the body properly warmed up and everybody is different in what they need to do to feel adequately warmed up prior to lifting, practicing, speed/conditioning sessions, testing, and competition.

## CHAPTER V. CONCLUSIONS

Proper warm-up prior to workouts, practice, and competition is vitally important in keeping subjects healthy and injury free. The information in this study can be used in developing appropriate modes of warm-ups depending on the activity. This information can also be used to determine if the desired warm-up will have an effect on the outcome of the activity.

Originally we hypothesized that static stretching and the control condition would result in the lowest performance. However, we found that the mini-band warm-up resulted in the worst performance in the 10m sprint time and that the control condition resulted in the best performance. All the other conditions resulted in no significant differences.

It is of no real surprise that the control group which consisted of a five minute jog had a statistical significance in improving 10 m sprint times. It is somewhat surprising that it didn't improve performance in the 20 m sprint as well. This may be where fatigue can be a contributing factor. Fatigue will be detailed later in this section. The results of the 10 m sprint time may also show that running prior to a weight lifting session may or may not be of benefit. Jogging prior to a sprint test, which is a test of power, was statistically significant in improving sprint times for the 10m sprint. It would lead to speculation that it could also have a positive impact on weight lifting, particularly in movements that require higher power output such as the Olympic lifts and its variations. It is also of note, to take into consideration, using a "build-up" sprint progression during warm-ups may be of benefit. "Build-up" progressions are where athletes begin at 50% of their top speed and progress towards higher percentages as the warm up nears its end. Appropriate rest times to prevent fatigue must be taken into account. This presumption could lend itself to a study of its own. It is important to consider all methods when designing appropriate warm ups for different types of activities.

Our results did not agree with Fletcher and Jones' (2004) results and our results also contradicted McMillian et al. (2006). The results of the McMillian et al., 2006 study are consistent with Bishops' (2003b) review of the literature, indicating that an active warm-up of moderate intensity is like to significantly improve short-term performance as long as fatigue is not induced (Bishop, 2003b; McMillian et al., 2006). Our results did agree with a study by Faigenbaum et al. (2006), where they found no significant differences in a seated medicine ball throw or 10 yard sprint times after completing static stretching and three dynamic warm-ups of varying intensity using a weighted vest.

Another point of discussion is the question, do statistically non-significant results found make a practical difference in the sport of soccer? When looking at the results of the BOMB throw, the mini-band had the worst performance with an average of 7.09 m per throw. The static stretching group had an average of 7.37 m per throw. That's nearly a foot difference. How is this information relevant? The ability to perform more work and have a higher power output repeatedly manifests itself in sport. In particular, the sport of soccer, when the ball is kicked with varying degrees of power and different intensities of sprints are regularly performed, the athlete who has the capacity for higher output has more potential. As athletes mature and progress in skill and ability (i.e. novice to professional to world class) the gap between athletes gets smaller. Therefore squeezing the most ability out of each athlete can influence the level they are able to compete. An athlete with a small work capacity, and who doesn't have the ability to produce power or strength, most likely won't be Division I or professional soccer player.

Another point of contention, does 1/100<sup>th</sup> of a second make a difference? In the 20 m sprint the mini-band had the worst performance with an average of 3.56 seconds. The control was the best with an average of 3.5 seconds. That six hundredth of a second could be the

difference from scoring the game winning goal and a defender blocking the game winning goal. It's a common phrase in sports, speed kills. Much evaluation of athletes is based around speed. The ability to accelerate quickly, break-away speed, and top end speed are evaluated in every sport. In soccer when the ball is played ahead, especially in a counter attack, the ball is played ahead of the intended target and the athlete runs on to the ball in a break-away. The athlete's ability to out run the defenders will provide the opportunity for an open shot. The ability to get the ball faster, get to the point of attack faster, accelerate from a dead stop faster is the difference between average and good, and good a great. Speed is speed and every hundredth, tenth, and second counts.

Many factors could have contributed to the lack of results. The population used participated in this study concurrent with their spring practice season. The participants had a competition on the weekend between testing. They also had practice and workouts during the week. This may have caused our results to be skewed due to fatigue.

The team competed in a 10 vs 10 soccer tournament on the weekend. Because the team was split into two teams for this particular competition, the girls accumulated more game time than normal. This competition was particularly taxing to the participants in the study. In an average soccer match, depending on position, one can expect to cover anywhere from 4-8 miles in a given competition. This competition wasn't the only thing they were participating during the testing period. They were also in their spring practice season, which allows them to have pre-season like practices. In addition to the practices and competitions, the participants were also completing workouts in the weight room two times per week. Some of the exercises performed at varying intensities were: squats, power cleans, clean pulls from the floor, and bench press. This accumulation of work during the testing period may have led to a large amount of fatigue.

Fatigue is a crucial factor to accommodate for in designing warm-ups and workouts. Having athletes do high intensity warmups could put them at higher risk for injury due to a fatigued state. Those athletes who are fatigued need to be appropriately warmed up (i.e. increased core temperature, increased neural drive, muscles loosened up). Fatigue leads to a decrease in performance, decrease in motivation, and high risk of injury. Fatigue can manifest itself in many ways: muscle soreness, muscle tightness, loss of flexibility, loss of strength, loss of reactivity of the muscles, strains, lessened desire to perform physical tasks, and lack of focus.

Some consideration needs to be taken into account when designing warm ups. For example, recovery modalities such as foam rolling, myofascial release, PNF stretching, and hydrotherapy can aid in preventing and reversing effects of fatigue. Proper sleep and nutrition also play an important role and must be noted. If an athlete isn't getting the nutrition and sleep he/she needs, then no matter what coaches and trainers do for the athletes benefit, it may not make a difference due to lack of basic needs for the human body to function. Assuming these things are in line, coaches and trainers must understand that every individual is different and may need to do more or less to properly feel warmed up prior to weight sessions, running session, practice, and competition. It may be beneficial to keep some time allotted for athletes to "do what they need to do" for recovery and warm up. Just like in many professions, jobs, and tasks, there is more than one way to reach a goal.

## REFERENCES

- Aagaard P., Simonsen E. B., Andersen J. L., Magnusson P., Dyhre-Poulsen P. (2002). Neural adaptation to resistance training: Changes in evoked V-wave and H-reflex responses. *Journal of Applied Physiology*, 97, 2309-2318.
- Bandy W., Irion J., & Briggler M. (1998). The effect of static stretch and dynamic range of motion training on the flexibility of the hamstring muscles. *Journal of Orthopedic and Sports Physical Therapy*, 27, 295–300.
- Behm D. (2004). Force maintenance with submaximal fatiguing contractions. *Canadian Journal of Applied Physiology*, 29, 274–290.
- Behm D., Bambury A., Cahill F., & Power K. (2004). Effect of acute static stretching on force, balance, reaction time, and movement time. *Medicine & Science in Sports & Exercise*, 36, 1397–1402.
- Behm D., Button D., & Butt J. (2001). Factors affecting force loss with prolonged stretching. *Canadian Journal of Applied Physiology*, 26, 261–272.
- Behm D., & Chaouachi A. (2010). A review of the acute effects of static and dynamic stretching on performance. *European Journal of Applied Physiology*, 111 (11), 2633-2651.
- Behm D. & Kibele A. (2007). Effects of differing intensities of static stretching on jump performance. *European Journal of Applied Physiology*, 101, 587–594.
- Bennett, A. (1984). Thermal dependence of muscle function. *American Journal of Physiology*, 247, R217-R229.
- Bishop D. (2003a). Warm up I: potential mechanisms and the effects of passive warm up on exercise performance. *Journal of Sports Medicine*, 33, 439–454.

- Bishop, D. (2003b). Warm up II: Performance changes following active warm up and how to structure the warm up. *Journal of Sports Medicine*, 33, 483-498.
- Brown, P., Hughes, M., & Tong, R. (2008). The effect of warm-up on high intensity, intermittent running using nonmotorized treadmill ergometry. *Journal of Strength and Conditioning Research*, 22(3), 801-808.
- Burkett, L., Phillips, W., & Ziuraitis, J. (2005). The best warm-up for the vertical jump in college-aged athletic men. *Journal of Strength and Conditioning Research*, 19(3), 673-676.
- Burnley, M., Doust, J., Carter, H., & Jones, A. (2001). Effects of prior exercise and recovery duration on oxygen uptake kinetics during heavy exercise in humans. *Journal of Experimental Physiology*, 86, 417-425.
- Cambridge, E., Sidorkewicz, N., Ikeda, D., & McGill, S. (2012). Progressive hip rehabilitation: The effects of resistance band placement on gluteal activation during two common exercises. *Clinical Biomechanics*, 27, 719-725.
- Carvalho, F., Carvalho, M., Simao, R., Gomes, T., Costa, P., Neto, L..., & Dantas, E. (2012). Acute effects of a warm-up including active, passive, and dynamic stretching on vertical jump performance. *Journal of Strength and Conditioning Research*, 26(9), 2447-2452.
- Christensen, B., & Nordstrom, B. (2008). The effects of proprioceptive neuromuscular facilitation and dynamic stretching techniques on vertical jump performance. *Journal of Strength and Conditioning Research*, 22(6), 1826-1831.
- Church, J., Wiggins, M., Moode, F., & Crist, R. (2001). Effect of warm-up and flexibility treatments on vertical jump performance. *Journal of Strength and Conditioning Research*, 15, 332-336.

- Clayton, M., Trudo, C., Laubach, L., Linderman, J., De Marco, G., & Barr, S. (2011). Relationships between isokinetic core strength and field based athletic performance tests in male collegiate baseball players. *Journal of Exercise Physiology Online*, 14(5), 20-30.
- Cornwell A., Nelson A., & Sidaway B. (2002). Acute effects of stretching on the neuro-mechanical properties of the triceps surae muscle complex. *European Journal of Applied Physiology*, 86, 428–434.
- Dalrymple, K., Davis, S. Dwyer, G.& Moir, G. (2010). Effect of static and dynamic stretching on vertical jump performance in collegiate women volleyball players. *Journal of Strength and Conditioning Research*, 24, 149-155.
- Duncan, M., & Hankey, J. (2010). Concurrent validity of the backwards overhead medicine ball throw as a test of explosive power in adolescents. *Medicina Sportiva*, 14(3), 103-108.
- Duncan, M., A-Nakeeb, Y., Nevill, A. (2005). Influence of familiarization on a backward, overhead medicine ball explosive power test. *Research in Sports Medicine: An International Journal*, 13(4), 345-352.
- Enoka, R. (2002). *Neuromechanics of human movement*. (4 ed.). Champaign, IL: Human Kinetics.
- Faigenbaum, A.D, McFarland, J.E, Schwerdtman, J, Nicholas A, Ratamess, Kang, J, & Hoffman, J. (2006). Dynamic warm-up protocols, with and without a weighted vest, and fitness performance in high school female athletes. *Journal of Athletic Training*, 41(4), 357-363.
- Fletcher, I.M., & Jones, B. (2004). The effect of different warm-up stretch protocols on 20 meter sprint performance in trained rugby union players. *Journal of Strength and Conditioning Research*, 18, 885–888.

- Fletcher I. (2010). The effect of different dynamic stretch velocities on jump performance. *European Journal of Applied Physiology*, 109, 491–498.
- Fowles J., Sale D., & MacDougall J. (2000). Reduced strength after passive stretch of the human plantar flexors. *Journal of Applied Physiology*, 89, 1179–1188.
- Frantz, T., & Ruiz, M. (2011). Effects of dynamic warm-up on lower body explosiveness among collegiate baseball players. *Journal of Strength and Conditioning Research*, 25(11), 2985-2990.
- Hamada, T., Sale, D., MacDougall, D., & Tarnopolsky, M. (2000). Postactivation potentiation, fiber type, and twitch contraction time in human knee extensor muscles. *Journal of Applied Physiology*, 88, 2131-2137.
- Herman, S.J., and Smith, D.T. (2008) Four-week dynamic stretching warm-up intervention elicits longer-term performance benefits. *Journal of Strength and Conditioning Research*, 22(4), 1286-97.
- Holt, B., & Lambourne, K. (2008). The impact of different warm-up protocols on vertical jump performance in male collegiate athletes. *Journal of Strength and Conditioning Research*, 22(1), 226-229.
- Jefferys, I. (n.d.). *Warm up revisited - the 'ramp' method of optimising performance preparation*. Retrieved from <http://www.allproperformance.co.uk/PSC - Ramp warm up.pdf>
- Kokkonen J, Nelson A, & Cornwell A. (1998). Acute muscle stretching inhibits maximal strength performance. *Research Quarterly of Exercise & Sport*, 69, 411–415.
- Koppo, K., & Bouckaert, J. (2001). The effect of prior high-intensity cycling exercise on the vo<sub>2</sub> kinetics during high-intensity cycling exercise is situated at the additional slow component. *International Journal of Sports Medicine*, 22, 21-26.

- McMillian, D., Moore, J., Hatler, B., & Taylor, D. (2006). Dynamic vs. static-stretching warm up: The effect on power and agility performance. *Journal of Strength and Conditioning*, 20(3), 492-499.
- Palozola, M., Koch, A., & Mayhew, J. (2010). Relationship of backwards overhead medicine ball throw with Olympic weightlifting performances. *Journal of Strength and Conditioning Research*, 24, 1-2.
- Power K., Behm D., Cahill F., Carroll M., Young W. (2004). An acute bout of static stretching: Effects on force and jumping performance. *Medicine & Science in Sports & Exercise*, 36, 1389–1396.
- Shalfawi, S., Enoksen, E., Tonnessen, E., & Ingebrigtsen, J. (2012). Assessing test-retest reliability of the portable Brower Speed Trap II testing system. *Kinesiology*, 44(1), 24-30.
- Shrier, I. (2004). Does stretching improve performance? A systematic and critical review of literature. *Clinical Journal of Sports Medicine*, 14, 267-273.
- Stockbrugger, B., Haennel, R. (2001). Validity and reliability of a medicine ball explosive power test. *Journal of Strength and Conditioning Research*, 15(4), 431-438.
- Young, W. (2007). The use of static stretching in warm-up for training and competition. *International Journal of Sports Physiology and Performance*, 2, 212–216.
- Young, W., & Behm D. (2002). Should static stretching be used during a warm-up for strength and power activities? *Journal of Strength and Conditioning Research*, 24, 33–37.
- Young, W., & Behm D. (2003). Effects of running, static stretching and practice jumps on explosive force production and jumping performance. *The Journal of Sports Medicine & Physical Fitness*, 43, 21–27.

## APPENDIX A. IRB APPROVAL FORM



February 20, 2014

FederalWide Assurance FWA00002439

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:**

- o prior to implementation of any proposed changes to the protocol (*Protocol Amendment Request Form*).
- o 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:**

- o 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*).
- o any significant new findings that may affect risks to participants.
- o 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

**INSTITUTIONAL REVIEW BOARD**

NDSU Dept 4000 | PO Box 6050 | Fargo ND 58108-6050 | 701.231.8995 | Fax 701.231.8098 | ndsu.edu/irb

Shipping address: Research 1, 1735 NDSU Research Park Drive, Fargo, ND 58102

NDSU is an EQ/AA university.

APPENDIX B. INFORMED CONSENT FORM

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.

Institutional Review Board
North Dakota State University
PROTOCOL #: HE14170
APPROVED: 2/20/14
EXPIRES: 2/19/15

**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: [ndsuirb@ndsu.edu](mailto:ndsuirb@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](http://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