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A Comparison of the Effects of Static Stretching With and Without Whole Body Vibration on Hip Flexion Range of Motion in College Age Males

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A COMPARISON OF THE EFFECTS OF STATIC STRETCHING WITH AND WITHOUT

WHOLE BODY VIBRATION ON HIP FLEXION RANGE OF MOTION IN COLLEGE AGE MALES

(TITLE)

BY

Jessica Lynn Wilson

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Jessica Lynn Wilson, B.S.

Eastern Illinois University, 2013

ABSTRACT

The purpose of this study was to compare the effects of a single bout of static stretching with and without whole body vibration on hip flexion range of motion in college age males. A second purpose was to determine whether any acute effects would persist after one hour of rest. It was hypothesized that there would be a significant increase from baseline to posttest hip range of motion with both static stretching only and static stretching with whole body vibration. Further, the improvement would be significantly greater with the addition of whole body vibration. It was also hypothesized that any positive effects would persist for at least one hour after a single bout of stretching in both groups with a greater retention of range of motion (ROM) being shown in the whole body vibration group.

Twenty-two collegiate males completed this study. Participants reported that they were untrained, defined as not participating in a consistent exercise routine within the previous six months. All of the participants were randomly assigned to either a static stretching only group (n=11) or the static stretching with whole-body vibration group (n=11). Baseline ROM measurements were conducted on both the right and left legs using a Leighton Flexometer following a five minute warm-up on a treadmill. Participants followed a static stretching protocol, depending on the group to which they were assigned. Immediately following completion of the stretches, the participants ROM was assessed. After one hour of rest, the participants ROM was assessed once more to determine if any changes in ROM persisted following one hour of rest. A mixed effects ANOVA was performed to determine if there was a significant difference between the right and left leg ROM measurements. After determining there was no significant difference between the right and left leg, the left leg was excluded from the analysis. Using only the right leg, a mixed effects ANOVA was performed comparing changes by group over the times tested. It was determined that there was no significant difference between the static stretching only group and the whole body vibration group over the three conditions with no significant interaction effect. The results also showed that there was a significant increase from pretest to posttest and a significant decrease from posttest to one hour posttest in ROM measurements. Although there was a decrease in ROM from immediate posttest to one hour posttest, the one hour post stretching values were significantly greater than the pre-stretching ROM. There were no significant differences between the two groups in the extent of these changes. It was concluded that the addition of whole body vibration to a bout of static stretching did not elicit a greater increase in hip flexion ROM over time than did static stretching alone.

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CHAPTER I

INTRODUCTION

The five health-related components of fitness are cardiorespiratory endurance, body composition, muscular strength, muscular endurance, and flexibility. Of these components, flexibility is one of the most frequently ignored of these components because people do not believe there are health issues related to poor flexibility of joints (Van den Tillaar, 2006). Adequate flexibility is important for activities of daily living (ADL) and contributes to improvements in joint range of motion and in level of physical function. As people age, flexibility tends to decrease and the tissues surrounding the joints become less elastic (Rees, Murphy, & Watsford, 2007). Although joint flexibility decreases with age, flexibility can be improved at any age and maintaining an adequate range of motion is encouraged for both sedentary and active individuals (American College of Sports Medicine, 2011).

The positive effects of improved flexibility are not as easily observed as improvements resulting from other fitness components such as cardiorespiratory endurance. The elastic component of muscles is lost as people age and become sedentary (Rees et al., 2007). The muscles are not used as often or not utilized in the full range of motion, therefore flexibility of the muscles and joints suffer (Turbanski, Hass, Friedrich, Duisberg, & Schmidtbleicher, 2005). Some benefits associated with adequate flexibility are: reduced risk of injuries, improvement in athletic performance, and pain relief (Bandy, Irion, & Briggler, 1997; Halburtsma, van Bolhuis & Geoken, 1996; Hartig & Henderson, 1997). Flexibility is defined by Zachezewski (1989) as the ability of a muscle to lengthen and the joints to move through a range of motion (ROM). Stretching is a way to increase flexibility by increasing the range of motion at a specific joint. Less than adequate flexibility has been associated with an increase in the susceptibility of injuries, especially in the hamstring muscles (Hartig & Henderson, 1997; Jonhagen, Nemech & Eriksson, 1994).

Three of the most common techniques utilized to improve flexibility include static and dynamic stretching, and proprioceptive neuromuscular facilitation (Funk, Swank, Mikla, Fagan, & Farr, 2003). Static stretching can be defined as the elongating of the muscle to tolerance and sustaining the position for a length of time (Anderson & Burke, 1991; Leibesman & Cafarelli, 1994). The individual performing static stretching does not stretch to the point of pain, but instead until there is mild discomfort. Static stretching is commonly used in activities such as yoga or pilates. A reason many coaches and physical education teachers use static stretching is because it is easily understood and can be performed independently by participants. Nelson & Bandy (2004) examined various types of stretching modalities and concluded that the gold standard for increasing flexibility has been shown to be static stretching.

Whole body vibration has been utilized for centuries. In Greek times, whole body vibrations were used as a method to speed up the healing process. In the 19th century physician John Harvey Kellogg brought back whole body vibration and used it as a method to treat many illnesses and diseases. In more modern times, Russian scientist Vladimir Nazarov was the first scientist to examine whole body vibrations for performance enhancement (Ciematnieks, Keizans, Prusis, & Cupriks, 2011). Recent research has been focused on whole body vibration and its utilization with resistance training, flexibility, balance, and coordination training (Issurin, 2005). Whole body vibrations are produced through the use of a vertically oscillating plate that has one of two displacements: reciprocating displacement on both sides of a fulcrum or displacement that is uniformly up and down (Hazell, Jakobi, & Kenno, 2007). There are two settings on a vibration plate, amplitude (mm), and frequency level (Hz). The different combinations of frequency and amplitude are what may alter the effect vibration has on the neuromuscular system. Issurin, Liebermann, and Tenenbaum (1994) used a vibration platform to examine the effect a vibration will have on the Central Nervous System. It was concluded that a frequency or amplitude that is too high, such as 100 Hz or greater can cause damage to neuromuscular structures. Frequencies of this magnitude and greater have been shown to negatively affect the body by increasing the excitability of the central nervous system and raise blood pressure. There have also been negative effects on the body, specifically a reduction in blood flow to fingers and toes, when the duration of exposure to whole body vibration is prolonged for the duration of greater than two hours (Issurin et al., 1994).

It is speculated that vibrations will stimulate muscle spindle fibers which in turn result in an involuntary reflex contraction through the tonic vibration reflex (TVR) (Hazell et al., 2007). The TVR occurs during vibration because the muscle will contract against the vibration, but once it reaches the "reflex" threshold, the muscle spindles will relax. At low vibration frequency, the threshold is reached almost instantaneously and the muscle spindles relax, allowing for the skeletal muscle to be stretched (Cheung, et.al., 2007). TVR has been utilized in a therapeutic approach on a locally selected muscle to stimulate the muscle fibers and create a relaxation effect in the subject (Issurin et al., 1994). During the 19th century, many physicians used vibration as a medical technique for quicker healing of a strained muscle (Issurin, 2005). Whole body vibration has been shown to enhance performance aspects in athletes and young adults. Previous research has suggested that strength, balance, coordination, vertical power and reaction time may be enhanced by pre-trial vibration (Ronnstad, 2009; Rees, Murphy, & Watsford, 2007; Issurin et al., 1994; Chung, Lin, Liu, Chaung, & Shiang, 2013; Erskine, Smillie, Leiper, Ball, & Cardinale, 2007).

Several studies have investigated static stretching and its effect on hamstring flexibility (Bandy et al., 1997; Halbertsma et al., 1996; Jonhagen et al., 1994; Nelson & Bandy, 2004), but few have studied hamstring flexibility changes with whole body vibration. There are many studies that attempted to examine which type of stretching modality had the greatest effect in increasing range of motion in the hamstring muscles. What has not been studied is the effect of static stretching alone versus static stretching with vibration on hamstring flexibility, and whether the effect of a single bout of stretching will persist after an acute amount of time.

Flexibility is a crucial component of physical fitness, health and mobility. A person who is not flexible is at greater risk for injuries of the joints and muscles that surround the joints. There are many different forms of stretching and many researchers are conducting studies to find the best method for different aspects of physical fitness. Many researchers agree that it is important to stretch muscles. There is a disagreement as to which mode is best, what the duration of a stretch should be, and how often to stretch.

Purpose

The purpose of this study was to compare the effects of a single bout of static stretching with and without whole body vibration on hip flexion range of motion in college age males.

A second purpose of this study was to determine whether any acute effects would persist after one hour of rest.

Hypothesis

It was hypothesized that there would be a significant increase from baseline to immediate post-stretching hip range of motion with both static stretching only and static stretching with whole body vibration. Further, the improvement would be significantly greater with the addition of whole body vibration. It was also hypothesized that any positive effects would persist at least one hour after a single bout of stretching in both groups with a greater retention of ROM being shown in the whole body vibration group.

Delimitations

This study included only untrained male college students, ages 18-24 years. Participants were chosen based on their current exercise routines. For the study, participants were untrained (not involved in any type of flexibility or resistance training program within the last 6 months). The hamstring flexibility test was used because poor range of motion in hip flexion and associated hamstring and lower back muscle groups and soft tissue are well known to be a source of movement limitation (Van den Tillaar, 2006). Untrained students were used so that previous flexibility, resistance or endurance training would not affect baseline range of motion.

Limitations

The limitations inherent in this study are as follows:

1. The participants of this study were limited to college age male volunteers from a Midwestern university. They were not selected by random sampling. Therefore, the findings of this study may not apply to other populations specifically those of a different age or gender or those with a history of flexibility training.

2. The use of whole body vibration is not a technique that currently has wide spread availability. Unfamiliarity with this modality may have the potential for impaired stretching performance due to the platform size and the whole body-vibration effect.

Assumptions

Inherent in this study was the assumption that all subjects accurately reported their exercise history. It was also assumed that all subjects stretched to mild discomfort to avoid injuries and accurately reported their bodily feelings during the protocol.

Definition of Terms

Flexibility: "The range of motion in a joint or series of joints that reflects the ability of the musculotendon structures to elongate within the physical limits of the joint." (Plowman & Smith, 2014).

Static Stretch: Static stretching has been defined as elongating the muscle to tolerance and sustaining the position for a length of time (Anderson & Burke 1991).

Tonic Vibration Reflex: A steady-state contraction of a muscle that has a vibration stimulus applied to it. The reflex is caused by the vibratory action of the muscle spindles. First the muscle will contract against the vibration, but once it reaches the reflex threshold, the muscle spindles will relax.

Muscle Spindles: Muscle spindles are skeletal muscle sensory organs that contribute to fine motor control and are involved in the positioning and movements of the body, particularly through the CNS. Muscle spindles monitor muscle length and rate of change in length. When stimulated, produce contraction of the muscle in which they are contained.

Leighton Flexometer: "is composed of a weighted 360 degree dial and a weighted pointer in a circular case. The Flexometer may be strapped to a segment to be measured with the dial locked at zero degrees at relaxed, anatomical position. Once the segment is moved the pointer is locked, giving a reading on the dial of the arc of motion." (Reese and Bandy, 2010)

CHAPTER II

REVIEW OF RELATED LITERATURE

The purpose of this study was to compare the effects of a single bout of static stretching with and without whole body vibration on hip flexion range of motion in college age males. A second purpose of this study was to determine whether any acute effects would persist after one hour of rest.

Flexibility is one of the five health-related components of fitness. Researchers have spent decades trying to find the best method for increasing range of motion and improving performance such as balance and agility. Various types of stretching modalitites have been investigated to determine which is the best method improve fitness components. Three of the most common techniques utilized to improve flexibility include static stretching, dynamic stretching, and proprioceptive neuromuscular facilitation (Funk et al., 2003).

Although the theory of using whole body vibration has also been around for many decades, it has only recently been considered as a technique to use for improving flexibility (Issurin, 2005). Whole-body vibration has been used in the past to enhance physical performance or as a proposed healing method for issues such as chronic low back pain (Rittweger et al., 2002; Hazell et al., 2007).

This chapter will present a review of related literature pertinent to the topic of this study. The review of related literature has been organized as follows: Static stretching: anatomical and physiological changes, neuromuscular and circulatory responses to vibration and the mechanisms of vibration effects.

Static Stretching: Anatomical and Physiological Changes

Three of the most common techniques utilized to improve flexibility include static and dynamic stretching, and proprioceptive neuromuscular facilitation (Funk et al., 2003). Static stretching can be defined as the elongating of the muscle to tolerance and sustaining the position for a length of time (Anderson & Burke, 1991; Leibesman & Cafarelli, 1994). The individual performing static stretching does not stretch to the point of pain, but instead until there is mild discomfort. Static stretching is commonly used in activities such as yoga or pilates. A reason many coaches and physical education teachers use static stretching is because it is easily understood and can be performed independently by participants. Nelson and Bandy, (2004) examined various types of stretching modalities and concluded that the gold standard for increasing flexibility has been shown to be static stretching.

There has been a debate with the application of static stretching concerning how long a stretch should be held and at what frequency a static stretch should be performed. The American College of Sports Medicine (2014) recommends that a flexibility routine be integrated at least five days per week and each stretch held for a total of 60 seconds. This is consistent with a study conducted by O'Sullivan, Murray, and Sainsbury (2009), who researched static and dynamic stretching as a warm-up with an acute increase in flexibility. The participants held each static stretch 30 seconds and performed them three times for a total of 90 seconds. This showed an increase in flexibility of the hamstrings for both the static and dynamic groups.

This is similar to a study conducted by Bandy et al., (1997) who studied the amount of time and frequency static stretching should be performed to increase hamstring flexibility. Ninety-three subjects completed the protocol of stretching five days per week at different times from 30-60 seconds. The authors concluded that a static stretch held for 30 seconds was just as effective as a stretch held 60 seconds.

Magnusson, Simonsen, Aagaard, and Kjaer (1996), investigated the biomechanical responses to repeated static stretches in the hamstring muscle. The researchers in this study suggested that there are two different phases to static stretching: a dynamic phase and a static tension phase. The dynamic phase is when the participant is going into the stretch, or when the muscle fibers are starting to pull joints move through its range of motion. The static phase of stretching is when the tendon length is held for some time. The researchers suggested that over time there would be a slight decline in tension of the muscle being statically stretched due to the viscoelastic stress relaxation factor. For their study, they used a KinCom dynamometer to passively stretch the hamstring muscle while the participant was sitting. Once the machine stretched the hamstring to the final position, it was held for 90 seconds for all stretches. After this was repeated five times with 30 second rest intervals, the subjects were analyzed on torque range of motion and velocity. The researchers concluded that if a muscle is passively warmed or preconditioned before stretching, the muscles can withstand greater length changes and force load before failing, and that slow twitch muscles have greater resistance and stiffness than fast twitch muscles.

It was suggested by Feland, Myre, and Merrill in their 2001 study of the effects of static stretching on range of motion, that the SSO group increase could be due to the inverse myotatic reflex which helps promote muscle relaxation and helps further the stretch. The muscles were stretched until the person felt mild discomfort for four repetitions. The authors speculated that due to the inverse myotatic reflex along with the four separate repetitions each participant performed, the muscle was able to relax and stretch further through ROM than without stretching.

It has been researched and determined from several investigations that hip range of motion comes from the flexibility of the hamstring muscles (Feland et al., 2001; Bandy et al.,1997; Halbertsma et al., 1996). This present study used static stretching in combination with vibration effects to determine whether hip range of motion would increase in an acute bout of static stretching. Issurin et al., (1994) along with Issurins study conducted in 2005, suggested that there are three different factors that contribute to flexibility increases with whole body vibration: neurological, circulatory, and thermoregulatory factors. It has been suggested that these factors not only contribute to an increase in range of motion, but also decrease the "pain threshold" that is associated with static stretching (Issurin et al., 1994).

Anatomically, there are structure in the muscle and tendons that are the reasons flexibility may increase or decrease, including elasticity and plasticity. The elastic component is what makes the muscle go back to its "original" length when it is stretched or strained. The plasticity component is how skeletal muscle adapts to repeated bouts of exercise or pressure. Whole-body vibration involves synchronous or side-alternating sinusoidal vibrations, which are transmitted to the body via platforms. It is believed to evoke muscle contractions via stretch reflexes in the muscle spindle system (Hazell et al., 2007). This reflex, also called the Tonic Vibration Reflex, has been utilized in a therapeutic approach on a locally selected muscle to stimulate the muscle fibers and create a relaxation effect in the subject (Issurin et al., 1994).

The myofibrils in each skeletal muscle fiber allow the muscle to be stretched and help extend the muscle length. These long muscle myofibrils are formed by sarcomeres that are the "muscle unit" of each skeletal muscle cell. Together, they allow the muscle fiber to be stretched (Chromiak & Antonio, 2008).

Presently, there are different factors such as fiber type and structures such as plastic and elastic components, myofibrils and sarcomeres that affect flexibility. Together these structures of the muscles are what help determine how flexible an individual may be. The research presented in this section demonstrated that with static stretching flexibility can improve. This section also suggested that hip range of motion comes from the hamstring flexibility, and the recommended duration of static stretching is 60 seconds.

Neuromuscular and Circulatory Responses to Vibration

Whole body vibrations activate muscle spindles and send a signal to the Central Nervous System (CNS). The CNS then sends the signal back to the muscles which causes an involuntary contraction of the muscles in response to the whole body vibration (McKee, 2012). Although for this study the VibePlate® was utilized to produce whole body vibration. There are many different types of vibration platforms used in other studies. Each type of vibration platform has two settings: frequency and amplitude. The different combinations of frequency and amplitude are what may alter the effect vibration has on the neuromuscular and circulatory systems.

In Issurin's review of vibrations and their applications in sport (2005) levels of whole body vibration were reviewed. What the research suggested is that a frequency or amplitude that is too high, such as 100 Hz or greater can cause damage to neuromuscular structures. frequencies at this level have been shown to negatively affect the body by increasing the excitability of the Central Nervous System and raise blood pressure. There have also been shown to have a reduction in blood flow to fingers and toes, when the duration of exposure to whole body vibration is prolonged for the duration of greater than two hours (Issurin et al., 1994; Lohman III, Petrofsky, Maloney-Hinds, Betts-Schwab, & Thorpe, 2007).

Erskin, Smillie, Leiper, Ball, & Cardinale, (2007) studied the neuroendocrine system and hormonal response during whole-body vibration. Methods for testing the hormonal response and neuromuscular response were taken by using salivary concentrations of cortisol and testosterone and maximal voluntary contractions immediately after one, two, and 24 hours following a protocol of ten mini squats on the vibration platform. The researchers used a frequency of 30Hz and concluded that this frequency caused no significant changes in testosterone and coritsol concentration. It was suggested that whole body vibrations at the frequency of 30Hz does not create a stressful stimulus for the neuroendocrine system for males.

Lohman III et al., (2007) examined the blood flow of the lower extremity during whole-body vibration stimulus. The study consisted of male and female subjects divided into three groups: vibration exercise, exercise only, vibration only. The first two groups were given a list of three exercises to perform, with vibration exercise group performing them on a vibration plate. The vibration only group rested with the calves on the vibration platform. Vibration frequencies were set at 30Hz for this study. Immediately following the intervention, subjects had post Doppler scans to show the blood flow of the participants. This study concluded that the whole body vibration did increase systolic blood flow for a minimum of ten minutes following intervention.

There are circulatory changes that occur when the body is exposed to whole body vibration. While there can be negative effects from whole body vibrations, it is important to note the research examined here demonstrated that, if done correctly, whole body vibration can elicit a positive response.

Mechanisms of Whole Body Vibration Effects

Whole-body vibration involves synchronous or side-alternating sinusoidal vibrations, which are transmitted to the body via platforms. It is believed to evoke muscle contractions via stretch reflexes in the muscle spindle system (Hazell et al., 2007). The concept of using whole body vibrations for rehabilitation has been used for decades, but has been more widely researched and known recently. Researchers have spent most of their time focusing on physical performance enhancements such as countermovement jump height, sprint times, and agility. Little research using whole body vibration up to this point has been focused on flexibility.

Power and Strength

Many studies have used whole-body vibrations to focus strictly on the power of the lower extremities in regards to strength or balance. Rees et al., (2007) studied the effects of whole-body vibration exercise on lower-extremity muscle strength and power in an older population. The study used a vibration of 26 Hz and had participants use the vibration platform to perform lower extremity body weight exercises. Participants trained eight weeks, three times per week with an exercise group and a vibration group. Baseline and posttest measurements were assessed for sit-to-stand test, five and ten meter walk, timed up-and-go test, stair mobility, and strength. The results were suggestive that for elderly individuals, whole body vibrations showed a significant increase in lower extremity strength and power. They believed the vibration training in combination with the body weight exercises, helped increase the muscle strength by stimulating the muscle fibers more than exercise alone and creating a greater response in the whole body vibration group.

Ronnestad (2009) examined the acute effects of whole body vibration (WBV) on lower body power in trained and untrained subjects. Frequencies of 20, 35, and 50 Hz were used along with a group with no vibration stimulus. Peak power during standing jump and countermovement jump were tested on a Smith machine immediately following 10 repetitions of half squats at 20kg. Results showed that vibration of 20 and 35 Hz did not produce significant increases in power for either the trained or untrained subjects, but vibration at 50Hz increased peak power in the untrained subjects. There was not a significant increase or decrease in the trained subjects at a frequency of 50 Hz. The control group that had no vibration effect did not have a significant increase or decrease in power.

There has been little research conducted on the upper extremity while using WBV. Hazell et al., (2007) focused on the upper and lower body while staticly and dynamically contracting muscles during whole body vibrations. The researchers used electromyography (EMG) during both bicep curls and mini squats to see the muscle activation during these movements. The vibrations for this study were set at 25, 30, 35, 40, and 45Hz. All of the vibrations showed muscle activation during the EMG, with the greatest activation being at the higher frequencies of 35, 40, and 45Hz. The main finding of their study was that with whole body vibration there was a significant increase in the muscle activity on the EMG machine for the lower and upper extremity. This finding would suggest that whole body vibration at those frequencies can stimulate the muscles more than exercising or actively contracting the muscle.

McKee (2012) used a VibePlate® in a research study focused on vertical jump height after subjects performed warm-up routines such as jogging on a treadmill, using a stationary bike, stretching, and standing on the VibePlate® at 40Hz. It was hypothesized that the whole body vibrations would increase vertical jump height significantly more than the other warm-up modes. Baseline measurements were assessed before the warm-up, immediately following wam-up, and after a rest period of 15 and 20 minutes. It was shown that immediately following the warm-up all of the methods were significantly beneficial in increasing jump height. After an acute rest period of 15 and 20 minutes it was shown that the VibePlate® was able to elicit a greater jump height than the stationary bike or jogging on the treadmill.

Balance and Flexibility

Chung et al., (2013) examined the effects of whole body vibration on lower extremity power and focused on balance control by using Tai Chi. Forty-eight young adults were split into three groups: Tai Chi Chuan with vibration, Tai Chi Chaun alone, and control. The Tai Chi Chaun with vibration group was on a vibration platform with frequency at 35 Hz three times a week for eight weeks performing standard Tai Chi Chaun motions. Each session lasted approximately 30 minutes. The Tai Chi Chuan group performed the same exercises just without the whole body vibration stimulus. A single leg stance was used to assess balance and countermovment jump was used to assess power. The results suggested that balance control was significantly improved in the participants in the combined vibration group by almost 15% more than the Tai Chi only group.

This study was consistent with a one year study conducted by Bogaerts, Verschueren, Delecluse, Claessens, and Boonen (2007) that showed an increase in balance and postural control with vibration training. Their study was longer than the study conducted by Chung et al. in that the study lasted twelve months total, with testing at three and six months. The study also used a vibration platform set at 35 Hz for their study and had the participants on the platform for a maximum of 30 minutes, performing static and dynamic lower extremity exercise. Like the previous study, this study assessed balance by using the single leg stance. The results were similar with that of Chung's that whole body vibration training increased balance and postural control.

Issurin et al. (1994) studied not only the performance aspect of force but also looked at flexibility with whole-body vibration stimulus. The researchers looked at trained athletes, and divided them into three different groups: exercises to strengthen arms and vibration stimulus on the lower extremity, vibration stimulus and strength exercises for upper extremity and strength exercises for lower extremity, and control group that did not participate in any vibration stimulus or strengthening program. Vibration stimulus was set at 44Hz with amplitude of 3mm. For flexibility, the researchers used a flex and reach test for spine and hip flexibility. The results were conclusive that the WBV stimulus increased force and flexibility significantly for the group with the vibration stimulus.

A study conducted on eighteen female hockey athletes by Chocrane and Stannard (2005) examined acute flexibility and power output using a hand dynamometer. There were three groups: whole body vibration, cycling, and control. The whole body vibration group did six static stretches on the vibration platform with frequency set at 26 Hz and the cycling group cycled for three minutes at 50 W. The results suggested that there was a significant interaction effect between the sit and reach test assessment and whole body vibration whereas there was no significant effect that cycling had on the sit and reach test.

The research conducted with whole body vibration has suggested that the addition of vibration can significantly improve power, strength, balance, and flexibility. The tonic vibration reflex has been suggested by many researchers as the reason for these improvements. As the tonic vibration reflex first contracts and then relaxes the muscle fibers, the muscle is able to stretch or elicit more power with the vibration effect. Of the research examined in this section, there was little conducted on flexibility or the acute effects that whole body vibration may have on one session of testing.

Rationale

No other investigations were identified in the literature that examined the acute range of motion effects of static stretching using whole body vibration among college age males. In the studies reviewed here, there was a wide range of frequencies and amplitudes used along with many different forms of vibration delivery. A frequency of 30 Hz and amplitude of 2mm was chosen for this study to reduce any negative circulatory responses during the stretching session.

CHAPTER III

METHODS

The purpose of this study was to compare the effects of a single bout of static stretching with and without whole body vibration on hip flexion range of motion (ROM) in college age males.

A second purpose of this study was to determine whether any acute effects would persist after one hour of rest.

Participants

The participants in this study were college males from a Midwestern university ranging in age from 18-24 years. Participant's eligibility was determined based on their current exercise routine. To be included, participants needed to be untrained (not involved in any type of flexibility or resistance training program within the last 6 months). Volunteers were excluded from participation if they had any kind of recent injury or surgery involving the hamstrings or lower back. Males were chosen as the only testing group so there were fewer limitations with gender differences in regard to body mechanics and flexibility measurements.

This study was approved by the university Institutional Review Board. All subjects gave their voluntary, informed consent prior to initiating their participation in this study. Participants were randomly placed into either the static only group or the static with vibration group.

Instrumentation

The main tools used for this study were a Leighton Flexometer and a VibePlate®. Both of these tools were used due to the availability of these devices. The Leighton Flexometer uses gravitational force and movement of a joint to determine degrees of range of motion. Figure 1 shows an illustration of the Leighton Flexometer and how it was used for this study. Accuracy of the device is said to be a 0.9. The Leighton Flexometer, as described by Reese and Bandy, 2010,

> "...is composed of a weighted 360 degree dial and a weighted pointer in a circular case. The Flexometer may be strapped to a segment to be measured with the dial locked at zero degrees at the extreme of the joints range of motion. Once the segment is moved the pointer is locked, giving a reading on the dial of the arc of motion."

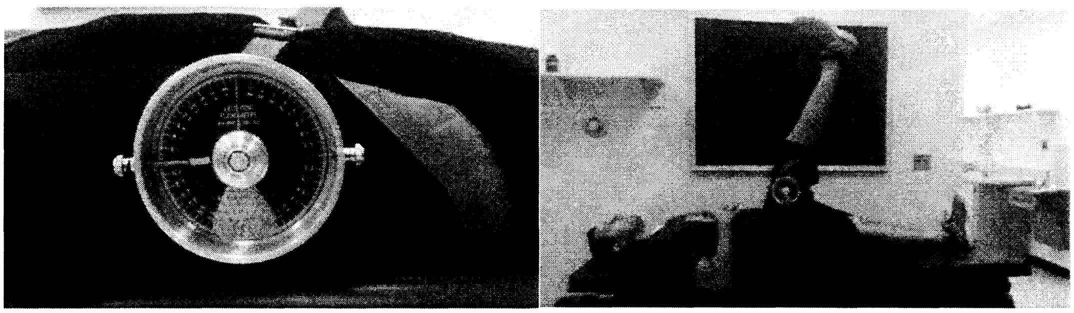


Figure 1. *Illustration of Leighton Flexometer and Range of Motion Test*

A VibePlate® vibration platform was also used for this study. A VibePlate® is a whole body vibration mechanism that can activate muscle spindles, sending a signal to the Central Nervous System (CNS). The CNS then sends the signal back to the muscles which causes an involuntary contraction of the muscles in response to the WBV (McKee, 2012). A computer stool three feet tall was used to assist the participants in one of the stretches. There was only one primary researcher in charge of testing. There was no other equipment used for this study. Figure 2 shows an illustration of the VibePlate® along with the frequency dial.

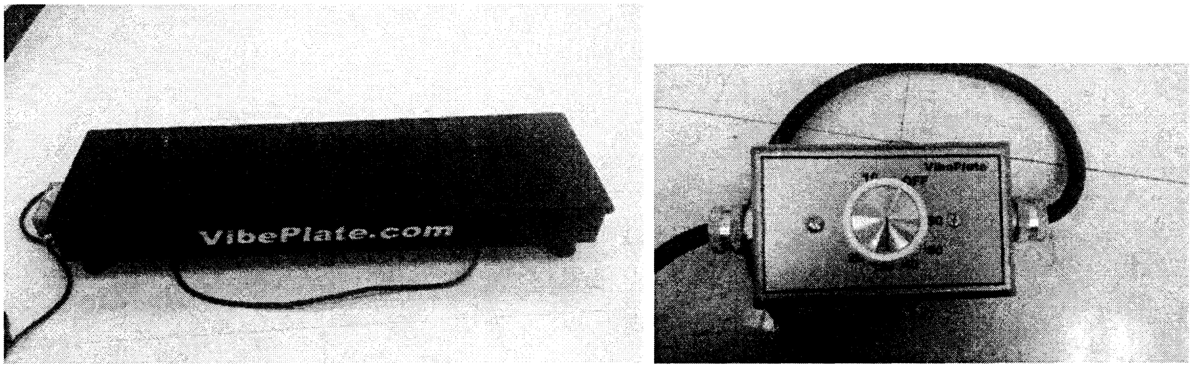


Figure 2. *Illustration of the VibePlate® and Frequency Dial*

Procedures

Each participant was assessed individually in the Human Performance Laboratory. After being instructed about their responsibilities for participation the informed consent was signed by both the participant and the primary investigator. Baseline flexibility measures assessed after a warm-up was performed by the participants. Measures of flexibility were repeated once again immediately after stretching and again one hour post stretching.

Following the review of stretches, participants then used a treadmill warm up. The treadmill was set at a speed of 3.0 and 0% incline. The participants were to walk without holding onto the sides of the treadmill for the duration of five minutes. Following the warm-up, participants were individually assessed for hip flexion range of motion of both the right and left hip and reviewed the stretching protocol.

Hip range of motion was assessed using a treatment table and Leighton Flexometer. The participants were asked to lie down in the supine position as close to the edge of the treatment table as possible. The participants were asked to relax both legs straight and arms relaxed at their sides. The Leighton Flexometer was placed so that it was tightened around the participant's quadriceps and hamstring muscles, aligned with the ball-and-socket joint of the hip, approximately half the distance between the greater trochanter and the patella. Once the pin was placed in the neutral position at zero, the participant was asked to actively move the hip with the Leighton Flexometer into flexion as far as possible. The opposite leg was to remain straight and relaxed, without allowing the knee to rise off of the mat. The second pin was put in place once the participant had reached full flexion and measurement was recorded. Following completion of one hip, the researcher did the same test on the opposing hip. Both the right and left hip flexion was tested for this study.

Following the hip range of motion baseline measurements, the researcher randomly placed the participants in either the static stretching only group or the static stretching with WBV group. Depending on what group they were placed in, they were given a short tutorial on how to perform each stretch. The static stretching with WBV group was also acclimated to the vibration platform and instructed on what to expect during the duration of the stretching protocol.

Stretching Protocols

The following protocols were performed individually during one session on the same day at the same time. The static stretching only (SSO) participants were then given a list of stretches they would be asked to perform. Each stretch was to be performed four times, holding each stretch for 15 seconds. Table 1 shows the list of stretches the participants in the SSO group were asked to perform (See Table 1). The researcher demonstrated these stretches for the participants and also assessed them before testing started to watch for proper technique.

The whole body vibration (WBV) participants received the same measurements of range of motion as the SSO group. After completing the warm-up, baseline measurements of ROM were assessed. The participants were then instructed on the proper technique for the stretches and also were acquainted to the vibration plate. The participants were then asked to stand on the vibration platform. The VibePlate® was then started by the head researcher with frequency at 30 Hz and amplitude at 2mm. The participant performed each stretch four times holding each stretch for 15 seconds. The stretches are listed in Table 2 (see Table 2).

Immediately following the stretching protocol, the researcher assessed the active range of motion of each hamstring. By using a Leighton Flexometer, the researcher measured the same way as the pre-test measurements. The participants were then allowed to leave the laboratory but given strict instructions not to perform physical activity for the next hour. An hour after the previous measurements, range of motion was assessed again to determine range of motion of the hamstrings.

Table 1.

Static Stretching Only Stretches

Standing Hamstring Lunge: Stand with one leg just in front of the other; Bend the back knee and rest your weight on the bent knee and front foot is on the heel.

Standing Hamstring Stretch: Stand with feet together, legs straight, and slowly bend down letting arms hang and reach towards the toes

Chair Hamstring Stretch: Place on leg on the seat of a folding chair. Leaving the other leg straight, bend towards the foot on the chair

Cross Leg Hamstring Stretch: Crossing one leg over the other and legs straight, bend down reaching towards toes. Repeat with opposite leg crossed

Standing Hip Flexor Stretch: Standing on one leg, pull the other leg to the chest holding the knee.

Table 2.

Static Stretching with Whole Body Vibration

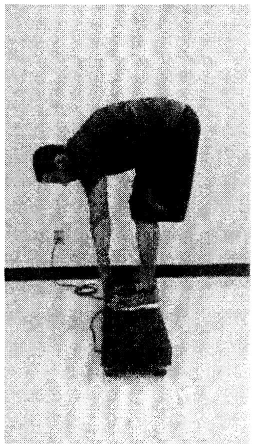
Standing Hamstring Lunge: Standing with both legs on a vibration plate with one leg just in front of the other; Bend the back knee and rest your weight on the bent knee

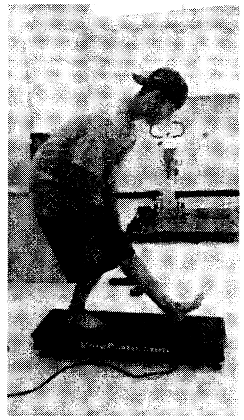
Standing Hamstring Stretch: Standing on vibration plate with feet together and slowly bend down letting arms hang and reach towards the toes

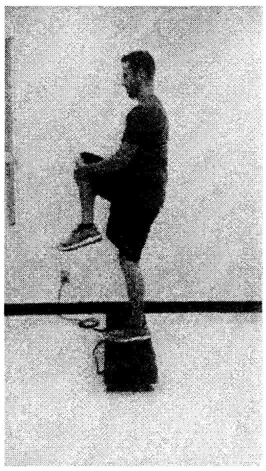
Chair Hamstring Stretch: With both legs on vibration plate, lean forward and out so that the participant is holding into the back of a fold up chair.

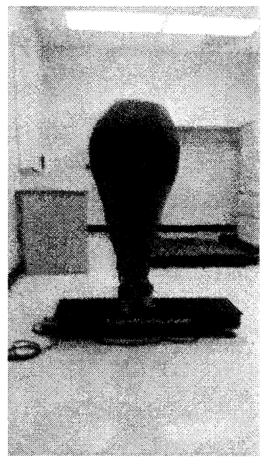
Cross Leg Hamstring Stretch: Standing with both legs on the vibration plate, crossing one leg over the other, bend down reaching towards toes. Repeat with opposite leg crossed

Standing Hip Flexor Stretch: Standing on one leg on the vibration plate, pull the other leg to the chest holding the knee.

A. 

B. 

C. 

D. 

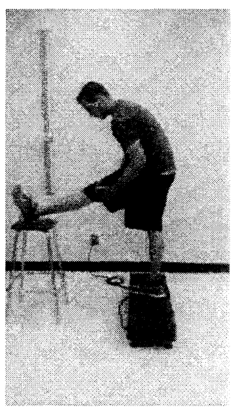
E. 

Figure 3. *Illustration of Static Stretches Performed on the VibePlate®*

A. Standing Hip Flexor Stretch, B. Standing Hamstring Lunge, C. Standing Hip Flexor Stretch, D. Cross Leg Hamstring Stretch E. Chair Hamstring Stretch

Data analysis

Data were first screened to determine if the assumptions were met for a mixed ANOVA. A mixed ANOVA was calculated to determine if there was a significant difference in flexibility between the right and left legs. Based on this conclusion, the left leg was eliminated from the data set because there was no significant difference between the legs and the sample size would not be affected. Following elimination of the left leg data, the assumptions were again tested using only the right leg data. A mixed ANOVA was conducted to test for differences between the stretching groups across time. Post-hoc tests were then conducted on significant ANOVA results. Finally, a paired samples t-test was conducted to test if there was a significant difference between the ROM measurements across time, without accounting for specific groups.

CHAPTER IV

RESULTS AND DISCUSSION

The purpose of this study was to compare the effects of a single bout of static stretching with and without whole body vibration on hip flexion range of motion (ROM) in college age males.

A second purpose of this study was to determine whether any acute effects would persist after one hour of rest.

It was hypothesized that there would be a significant increase in baseline to immediate post-stretching hip range of motion with both static stretching only and static stretching with whole body vibration. Further, the improvement would be significantly greater with the addition of whole body vibration. It was also hypothesized that any positive effects would persist for at least one hour after a single bout of stretching in both groups with a significantly greater retention of ROM being shown in the whole body vibration group.

Results

Twenty-two collegiate males completed this study. Participants reported that they were untrained, defined as not participating in consistent exercise routine within the previous six months. All of the participants were randomly assigned to either a static stretching only group (SSO) or the static stretching with whole-body vibration group (WBV).

Comparison of Right Versus Left Leg Over Time

All assumptions were tested to determine whether they were met for a mixed effects ANOVA. The assumption of normality was tested by computing the z-scores for skewness and kurtosis which were 0.0 and -2.9 respectively, indicating the data are within normal range. The assumption of sphericity was examined by performing Mauchley's test for sphericity (Mauchly's W=.97, p=.55) indicating that the variances of the difference scores between the right and left leg are equivalent. Finally the assumption of homogeneity of variance was assessed using Levene's test for equality of variances between legs for pretest ($F(1,42) = .04$, $p=.85$) posttest ($F(1,42) =.28$, $p=.60$) and one hour following ($F(1,42) = .24$, $p=.63$) indicating the variances are homogeneous. With all of the assumptions met, a mixed ANOVA ($p<.05$) was then completed comparing range of motion as measured at three time points with leg as the between-subjects factor. There was no significant difference between ROM measurements and which leg was used ($p=0.92$). Post hoc tests using pairwise comparison were calculated with the significance level using a Bonferroni adjustment set at ($p=.05/3=0.017$). The post hoc tests determined that there was a significant difference in ROM over the times assessed ($p<.001$).

Table 3. *Means and Standard Deviations for Each Leg Over Time*

	SSO (n=11)	WBV (n=11)
Pretest Hip ROM Left	76.3 ± 8.2	75.5 ± 13.4
Pretest Hip ROM Right	72.5 ± 8.2	76.1 ± 13.5
Posttest Hip ROM Left	83.0 ± 8.4	85.9 ± 12.9
Posttest Hip ROM Right	79.2 ± 7.0	85.5 ± 11.9
One hour Hip ROM Left	79.0 ± 9.1	80.8 ± 14.4
One hour Hip ROM Right	75.1 ± 5.5	80.5 ± 12.9

Range of motion measurements are shown in Table 3 for the left and right leg. From these results, it was determined that there was not a significant difference in ROM between the right and left legs. Therefore, the left leg measurements were eliminated from the data set because there was no significant difference between the legs and the sample size would remain the same. Following elimination of the left leg data, assumptions were again tested using only the right leg data for a mixed ANOVA.

Comparison of Group ROM over Time

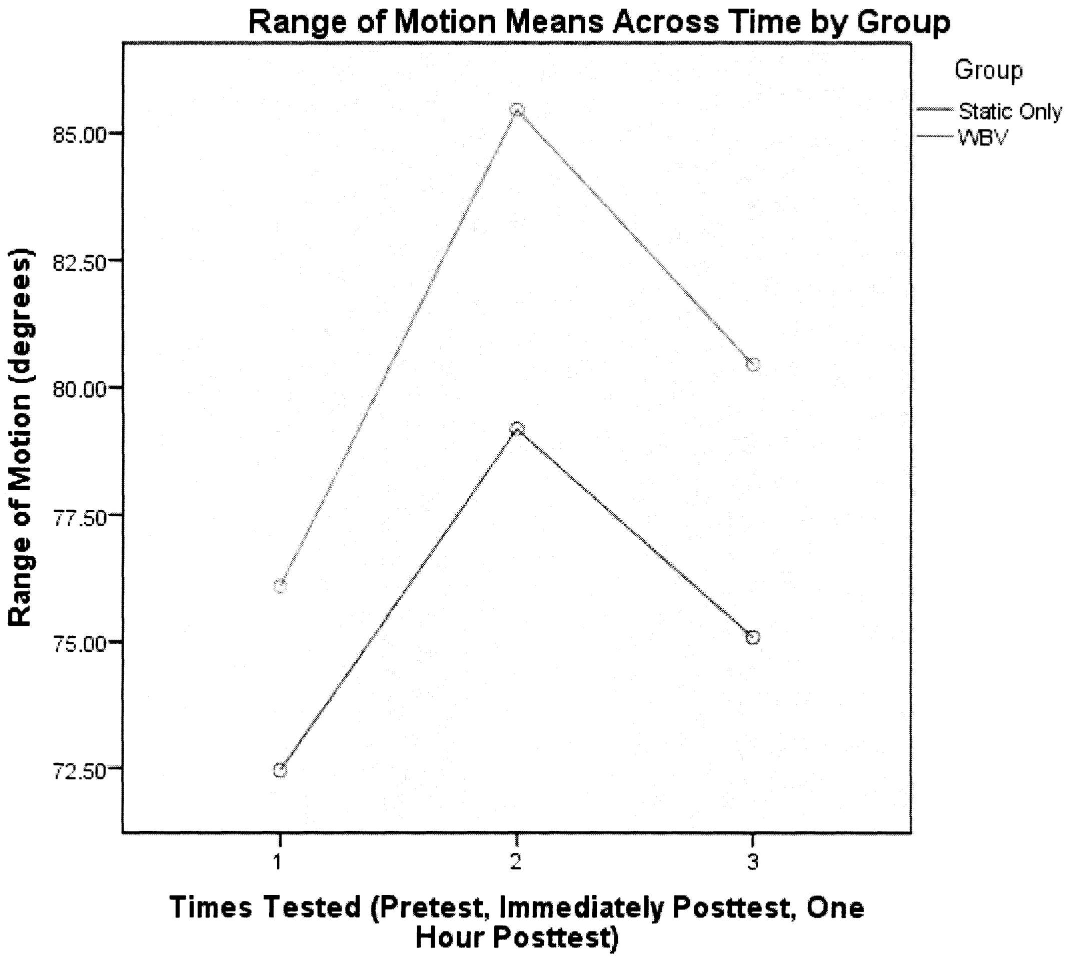
Following elimination of the left leg data from the analysis, assumptions were again tested using only the right leg data for a mixed ANOVA with the between subjects factor being the conditions for which the participants were assessed for ROM. Again, all assumptions were met: the assumption of normality, z-scores for skewness and kurtosis were 0.0 and -2.3 respectively, Mauchley's test (Mauchley's W=.93, p=.49), homogeneity of variances were tested using Levene's test for equality of variances between groups for pretest (F(1, 20)= .97, p=.34) posttest (F(1, 20)= 1.16, p=.29) and one hour postest, (F(1, 20)= 2.490, p=.13) were met to indicate the variances are homogenous.

Descriptive statistics for hip ROM by group and test condition are shown in Table 4. Figure 4 shows mean changes in ROM over time by group.

Table 4. *Descriptive Statistics by Group*

	Group	Mean	Std. Deviation
Pretest	SSO	72.5	8.2
	WBV	76.1	13.5
Posttest	SSO	79.2	7.0
	WBV	85.5	11.9
One Hour Posttest	SSO	75.1	5.5
	WBV	80.5	12.9

Figure 4. *Comparing Range of Motion Means Over Time For Both Groups*



A mixed ANOVA was completed comparing flexibility measures at three time points with the different groups as the between subjects factor. There was no significant difference between the ROM measurements of the different groups across time (p=0.24) and there was no significant interaction between the two groups across the three times. There was however a significant effect for time for which a paired samples t-test was conducted to determine the significance across time.

A paired samples t-test was conducted to determine if there would be a significant difference in ROM between times tested, not factoring in the different groups. This measurement did not take into account which group the participants were in, it was only a determination of the difference in ROM over the times tested. Without looking at groups as the between subjects factor, the results showed that there was a significant difference from pretest to posttest ($t(21)=-6.841$, $p<.001$), from posttest to one hour following ($t(21)=4.073$, $p=.001$) and pretest to one hour following ($t(21)=-3.783$, $p=.001$) in hip ROM measurements.

Discussion of Results

It was hypothesized that there would be a significant increase in baseline to post-stretching hip range of motion with both static stretching only and static stretching with whole body vibration. Further, the improvement would be significantly greater with the addition of whole body vibration. It was also hypothesized that any positive effects would persist for at least one hour after a single bout of stretching in both groups with a greater retention of the stretching induced increase being shown in the whole body vibration group.

Both of the groups demonstrated an increased hip ROM from pretest to immediately posttest. However, both groups had a significant decrease in ROM from immediately posttest to one hour posttest, although the one hour posttest ROM was still significantly greater than pretest values. There was no significant difference over time between the SSO group and the WBV group. The results of this study did support the hypothesis that there would be a significant increase in baseline to post-stretching hamstring flexibility and hip range of motion with both static stretching only and static stretching with whole body vibration. However, the findings from this study did not support the hypothesis that the improvement in ROM would be significantly greater with the addition of whole body vibration. These results indicate that the addition of whole body vibration at 30 Hz and 2 mm amplitude to a stretching protocol to improve hip ROM provides no additional acute benefit beyond static stretching alone.

No previous studies were found comparing the acute effects of one session of whole body vibration with or without static stretching with effects on ROM. There were, however, reports of flexibility training using whole body vibration with flexibility exercises.

Van den Tillarr (2006) examined the effects of whole body vibration with flexibility training by using a contract and release method instead of static stretching. There were two groups: the whole body vibration group and a control group that did the same stretches without vibration. The results of this four week training study showed that whole body vibration training was more significant than a control group because whole body vibration training increased by 30% and the control group by 15%. Bissonnette, Weir, Leigh, and Kenno (2010) also researched the effect of whole body vibration on flexibility training. After eight weeks of vibration training, flexibility for the upper and lower extremities showed significant improvements. Instead of static stretching, this study used dynamic stretching exercises with vibration. The vibration platform was set at frequencies anywhere between 30-45 Hz . The mode of assessing flexibility was a sit and reach test. There was a 70.4% increase in upper and lower extremity flexibility after the training period. It could be suggested based upon these results in relation with the present study that there may need to be more than one session of vibration to elicit significant lasting effects.

It was suggested by Feland et al. in their 2001 study of the effects of static stretching on range of motion, that the SSO group increase could be due to the inverse myotatic reflex which helps promote muscle relaxation and helps further the stretch. The muscles were stretched until the person felt mild discomfort for four repetitions. The authors speculated that due to the inverse myotatic reflex along with the four separate repetitions each participant performed, the muscle was able to relax and stretch further through ROM than without stretching. The whole body vibration group not only experienced the myotatic reflex from the four repetitions of static stretching, but also experienced effects from the vibrations such as the tonic vibration reflex. This could have allowed the subject's muscle spindle fibers to relax and lower the "pain threshold" to allow the subject to stretch further than without the vibration (Issurin, 2005).

The increase in hip range of motion observed from pretest to immediately posttest can be due to the plasticity of the hamstring muscles being stretched. This is supported with other studies conducted on flexibility of the hamstrings with static stretching both with and without whole body vibrations. Whole-body vibration involves synchronous or side-alternating sinusoidal vibrations, which are transmitted to the body via platforms. It is believed to evoke muscle contractions via stretch reflexes in the muscle spindle system (Hazell et al.,2007). At low vibration frequency, the threshold is reached almost instantaneously and the muscle spindles relax, allowing for the skeletal muscle to be stretched (Cheung, et.al., 2007) This reflex, also called the Tonic Vibration Reflex, has been utilized in a therapeutic approach on a locally selected muscle to stimulate the muscle fibers and create a relaxation effect in the subject (Issurin et al.,1994).

Since there was not a significant difference found in this study between the two groups it was suggested that whole body vibration does not give a greater effect than static stretching only. A study conducted by Pel et. al (2009) suggested that as the whole body vibration transmits through the joints of the body some frequency is lost at the next joint. For example, their study examined the Powerplate, another vibration platform, and its level of frequency transmitted through each joint with a participant standing on it. It was suggested in their research that at a frequency of 25 Hz, the vibration effect would be strongest at the ankle and be reduced approximately 6-10 times at the knee and the hip. For the current study it could then be suggested that the frequency level was not high enough to elicit a greater effect than static stretching only.

In the present study, the participants wore tennis shoes, all different makes and thickness. In a study conducted by Ronnestad (2009), the participants all wore the same shoes during protocol on a vibration platform, since the vibration effect may be diminished depending on the thickness and rigidity of the shoes worn. This could have been another factor as to why the whole body vibration did not have a greater effect over static stretching only.

Although both of the groups demonstrated an increase over time from pretest to immediately posttest, there was a significant decline in ROM measured from posttest to one hour following the protocol. While there was a decrease in ROM after one hour, enough of the effects persisted so that the ROM was still significantly greater than the pretest values. This could be due to the elastic property of the muscle. One session of stretching may not be enough to show lasting effects like a training method of stretching would. Much like the studies conducted by Bandy, et al. 1997 and Feland et al., 2001, frequency of stretching is what seems to have the greatest effect on over all ROM measurements.

CHAPTER V

SUMMARY AND CONCLUSION

This study was designed to compare the acute effects of static stretching only with static stretching using whole body vibration on the VibePlate® in college age males. It was hypothesized that there would be a significant increase in baseline to immediate post-stretching hip range of motion with both static stretching only and static stretching with whole body vibration. Further, the improvement would be significantly greater with the addition of whole body vibration. It was also hypothesized that any positive effects would persist for at least one hour after a single bout of stretching in both groups with a greater retention of ROM being shown in the whole body vibration group.

Twenty-two males participated in the study and were randomly divided into two groups, static stretching only (n=11) and static stretching with whole body vibration (n-=11). Each group completed baseline hip ROM measurements using a Leighton Flexometer, a warm-up of walking on the treadmill at 3.0 mph 0% grade, the same stretching protocol in respective groups, and ROM testing immediately posttest and one hour posttest.

Summary of Findings

This study investigated the acute effects of static stretching and static stretching with vibration in college age males. The results determined that both static stretching and static stretching with whole body vibration did acutely increase hip range of motion (ROM). However, the findings demonstrated that there was not a significant difference between the two methods. In both static stretching only and static stretching with whole body vibration there was a significant increase in ROM from prettest to immediately posttest, and a significant decrease in ROM from immediately posttest to one hour posttest but there was no significant difference between groups among these testing conditions. The one hour post-stretching ROM, while diminished from the immediate post stretching values, was still greater than baseline levels demonstrating that a portion of the effects of the acute bout of stretching persisted in both groups with no greater retention of benefits in the stretching with vibration group than in the stretching only group.

Conclusion

It was hypothesized that there would be a significant increase in baseline to post-stretching hamstring flexibility and hip range of motion (ROM) with both static stretching only and static stretching with whole body vibration. Further, the improvement would be significantly greater with the addition of whole body vibration. It was also hypothesized that any positive effects would persist at least one hour after a single bout of stretching in both groups with a greater retention of ROM being shown in the whole body vibration group.

The findings of this current study of twenty-two untrained males did support the hypothesis that there would be a significant increase in hip ROM from baseline to immediately posttest, but did not support the secondary hypothesis that one method would be more effective than the other in improving ROM. The findings did not support the hypothesis that whole body vibration would show more of an effect and only partially supported the hypothesis that any effects would persist for an hour following the stretching protocol as there was some attenuation of the ROM from immediate to one hour post test. However, the one hour ROM was significantly greater than the pretest values. Based on these results the following conclusions were made:

- Static stretching improved hip range of motion immediately following stretching with no additional benefit from the addition of whole body vibration.
- Only a portion of the improvement in hip ROM results from static stretching was retained after one hour with no additional benefit from adding vibration to the stretching protocol.

Suggestions for Future Research

Further research in this field would benefit from a larger sample size of both genders with a greater range of age and other populations such as older adults, children, and individuals with chronic disease. It is also suggested that different methods of providing whole body vibration including different vibration devices and frequencies be evaluated. In addition, investigating different techniques for improving flexibility be tested in conjunction with vibration such as dynamic or proprioceptive neuromuscular facilitation.

WORKS CITED

Anderson B., & Burke, E. R. (1991). Scientific, medical, and practical aspect of stretching. *Clinical Sports Medicine. 10,* 63-86.

Bandy, W. D. & Irion, J. M., & Briggler, M. (1997). The effect of time and frequency of static stretching on flexibility of the hamstring muscles. *Journal of the American Physical Therapy Association. 77,* 1090-1096.

Bissonnette, D.R., Weir, P.L., Leigh, L., & Kenno, K. (2010) The effects of a whole-body advanced vibration exercise program on flexibility, balance, and strength in seniors. *Physical and Occupational Therapy in Geriatrics. 28(3).* 225-234.

Bogaerts, A., Verschueren, S., Delecluse, C., Claessens, A.L., & Boonen, S. (2007). Effects of whole body vibration training on postural control in older individuals: A 1 year randomized controlled trial. *Gait and Posture, Science Direct. 26*. 309-316.

Cheung, W., Mok, H., Qin, L., Sze, P., Lee, K., & Leung, K. (2007). High-frequency whole-body vibration improves balancing ability in elderly women. *Archives of Physical Medicine and Rehabilitation. 88*. 852-857.

Chocrane, D.J., Stannard, S.R. (2005). Acute whole body vibration training increases vertical jump and flexibility performance in elite female field hockey players. *British Journal of Sports Medicine. 12*. 19-26.

Chromiak, J.A. & Antonio, J. (2008). Skeletal Muscle Plasticity. *Essentials of Sports Nutrition and Supplements. 1*. 21-52.

Chung, P., Lin, G., Liu, C., Chaung, L., & Shiang, T. (2013). The effects of Tai Chi Chuan combined with vibration training on balance control and lower extremity muscle power. *Jounral of Sports Science and Medicine. 12*. 19-26.

Ciematnieks, U., Keizans, N., Pruisis, S., & Cupriks, L. (2011). Vibrostimulation in bobsleigh, *Lase Journal of Sport Science. 2*(1). 3-12.

Erskine, J., Smillie, I., Leiper, J., Ball, D., & Cardinale, M. (2007). Neuromuscular and hormonal responses to a single session of whole body vibration exercise in healthy young men. *Clinical Physiology and Functional Imaging. 27*(4). 242-248.

Feland, J. B., Myrer, J. W., & Merrill, R. M. (2001). Acute changes in hamstring flexibility: PNF versus static stretch in senior athletes. *Physical Therapy in Sport*. 2. 186-193.

Funk, D. C., Swank, A. M., Mikla, B. M., Fagan, T. A., & Farr, B.K. (2003). Impact of prior exercise on hamstring flexibility: A comparison of proprioceptive neuromuscular facilitation and static stretching. *Journal of Strength and Conditioning Research*, *22,* 489-492.

Halbertsma, J. P., van Bolhuis, A., & Geoken, L. N. (1996). Sport stretching: Effect on passive muscle stiffness of short hamstrings. *Archives of Physical Medical Rehabilitation. 77,* 688-692.

Hartig, D. E., & Henderson, J. M. (1997). Increasing hamstring flexibility decreases lower extremity overuse injuries in military basic trainees. *The American Journal of Sports Medicine. 27,* 173-176.

Hazell, T.J., Jakobi, J.M., & Kenno, K.A. (2007). The effects of whole-body vibration on upper- and lower-body EMG during static and dynamic contractions. *Journal of Applied Physiology Nutrition and Metabolism. 32,* 1156-1163.

Issurin, V.B., Liebermann, D.G., & Tenenbaum, G. (1994). Effect of vibratory stimulation training on maximal force and flexibility. *Journal of Sports Sciences. 12*. 561-566.

Issurin, V.B. (2005). Vibrations and their applications in sport. *Journal of Sports Medicine and Physical Fitness. 45*(3). 324-336.

Jonhagen, S., Nemech, G., & Eriksson, E. (1994). Hamstring injuries in sprinters- The role of concentric and eccentric hamstring muscle strength and flexibility. *The American Journal of Sports Medicine. 22* (2), 262-266.

Leibesman, L., & Cafarelli, E. (1994). Physiology of range of motion in human joint: A critical review. *Critical Review Physical Rehabilitation Medicine. 6*, 131-160.

Lohman III, E.B., Petrofsky, J.S., Maloney-Minds, C., Betts-Schwab, H., & Thorpe, D. (2007). The effect of whole body vibration on lower extremity skin blood flow in normal subjects. *Medical Science Monitor Clinical Research. 13*(2). 71-76.

Magnusson, S.P., Simonsen, E.B., Aagaard, P., & Kjaer, M. (1996). Biomechanical responses to repeated stretches in human hamstring muscle in vivo. *American Journal of Sports Medicine. 24* (5). 622-628.

McKee, Patrick. (2012). The actue effects of whole body vibration and vertical jump height.*Eastern Illinois University.* 1-34.

Nelson, R. T., & Bandy, W. D. (2004). Eccentric training and static stretching improve hamstring flexibility of high school males. *Journal of Athletic Training. 39* (3). 254-258.

O'Sullivan, K., Murray, E., & Sainsbury, D, (2009). The effect of warm-up, static stretching, and dynamic stretching on hamstring flexibility in previously injured subjects. *BMC Musculoskeletal Disorder. 10* (37). 1-9.

Pescatello, L.S., Arena, R., Riebe, D., & Thompson, P.D. (Eds.). (2014). *ACSM's guidelines for exercise testing and prescription*. Baltimore, MD. American College of Sports Medicine.

Pel, J.J.M., Bagheri, J., van Dam, L.M., van den Beg-Emons, H.J.G., Horemans, H.L.D., Stam, H.J., & van der Steen, J. (2009). Platform accelerations of three different whole-body vibration devices and the transmission of vertical vibrations to the lower limbs. *Journal of Medical Engineering and Physics.* 1-8. doi: 10.1016/j.medengphy.2009.05.005.

Plowman, S.A. & Smith, D.L., (2014). Exercise physiology for health, fitness and performance (4th ed.) Lippincott, Williams & Wilkins.

Reese, N. B., & Bandy, W.B., (2010). *Joint Range of Motion and Muscle Length Testing, Second Edition*. St. Louis, MO. Saunders

Rees, S.S., Murphy, A.J, & Watsford, M.L. (2007). Effects of whole-body vibration exercise on lower-extremity muscle strength and power in an older population: A randomized clinical trial. *Journal of the American Physical Therapy Association. 88*(4). 462-470.

Rittweger, J., Just, K., Kautzsch, K., Reeg, P., & Felsenberg, D. (2002). Treatment of chronic lower back pain with lumbar extension and whole-body vibration exercise. *SPINE. 27*(17). 1829-1834.

Ronnstad, B.R. (2009) Acute effects of various whole-body vibration frequencies on lower-body power in trained and untrained subjects. *Journal of Strength and Conditioning Research. 23*(4), 1309-1315.

Turbanski, S., Hass, C.T., Friedrich, A., Duisberg, P., & Schmidtbleicher, D. (2005). Effects of random whole-body vibration on postural control in Parkinson's disease. *Research in Sports Medicine- An International Journal. 3*. 243-256.

Van den Tillaar, R. (2006). Will whole-body vibration training help increase the range of motion of the hamstrings? *Journal of Strength and Conditioning Research.* 20(1). 192-196.

Zachezewski, J. E. (1989). Improving flexibility. Philidelphia, PA: JB Lippincott. 698-699.

APPENDIX A

CONSENT TO PARTICIPATE IN RESEARCH

A comparison of the effects of static stretching with and without whole body vibration on hip flexion range of motion in college age males

You are invited to participate in a research study conducted by Jessica Wilson B.S., from the Kinesiology and Sports Studies Department at Eastern Illinois University. Your participation in this study is entirely voluntary. Please ask questions about anything you do not understand before deciding whether to participate.

PURPOSE

The purpose of this project is to compare changes in range of motion for static stretching alone versus static stretching with full body vibration.

PROCEDURES

If you volunteer to participate in this study, you will be asked to:

1. Complete a pre-participation screening including information about your exercise history.
2. You will be randomly assigned to either a static stretching only group or a static stretching with full body vibration group. The testing will take approximately 1 hour.
3. You will be initially assessed for range of motion in hip flexion, perform a short warm-up, followed by the stretching procedure assigned to you.
4. Following the stretching procedure you will be reassessed for range of motion. An hour after the stretching session you will be assessed for flexibility once more to compare with both the baseline and immediate post stretching values.

POTENTIAL RISKS AND DISCOMFORTS

While the intensity of exercise in the form of flexibility exercise is no greater than moderate and is equivalent to what would be expected from participation in a typical stretching program, it is possible that you may experience some minimal muscle soreness as a result of participation in this study. You may experience some mild discomfort as a result of the stretching protocol,

It will be necessary for the test administrator to physically touch your legs, hips and arms/shoulders to position you properly and to stabilize your limbs, back or pelvis to isolate the joint movement being tested.

The risk of injury from your involvement with this study is minimal. There will be no financial compensation or treatment available should you be injured as a result of participating in this research study. If you believe that you have sustained an injury that requires medical treatment, you are directed to your personal health provider or EIU health services.

POTENTIAL BENEFITS TO SUBJECTS AND/OR TO SOCIETY

There are no specific benefits to you expected from your participation. You may gain knowledge of stretching protocols and are welcome to ask questions at any time. You may find the information provided about your hip and low back flexibility to be beneficial by increasing your awareness of this aspect of your physical fitness. You will be told your results if you wish to know after all measurements have been taken. The findings of this study may provide a broader benefit by contributing to the body of knowledge relating to flexibility and stretching protocols and information about the effect of exercise on flexibility.

CONFIDENTIALITY

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. Confidentiality will be maintained by keeping your file stored in a computer file with only the investigators having the password, and by coding all data files that are used for statistical analysis with a subject number rather than with your name. Reports written about this study will not contain any information about individuals or any information from which you can be identified as a participant. The reports will not contain your name.

PARTICIATION AND WITHDRAWAL

Participation in this research study is voluntary and not a requirement or a condition for being the recipient of benefits or services from Eastern Illinois University. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind or loss of benefits or services to which you are otherwise entitled. There is no penalty if you withdraw from the study and you will not lose any benefits to which you are otherwise entitled.

IDENTIFICATION OF INVESTIGATORS

If you have any questions or concerns about this research, please contact:

Primary Investigator

Jessica Wilson B.S.
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618-322-5478

Faculty Adviser

Dr. Brian Pritschet
blpritschet@eiu.edu
217-581-7586

RIGHTS OF RESEARCH SUBJECTS

If you have any questions or concerns about the treatment of human participants in this study, you may call or write:

Institutional Review Board

Telephone: 217-581-8576

Eastern Illinois University

600 Lincoln Avenue Charleston, IL 61920

Email: eiuirb@www.eiu.edu

You will be given the opportunity to discuss any questions about your rights as a research subject with a member of the IRB. The IRB is an independent committee composed of members of the University community, as well as lay members of the community not connected with EIU. The IRB has reviewed and approved this study.

I voluntarily agree to participate in this study. I understand that I am free to withdraw my consent and discontinue my participation at any time. I have been given a copy of this form.

X____

Printed name of the participant

X____

Signature of participant Date

I, the undersigned, have defined and fully explained the investigation to the above subject.

X

Signature of Investigator Date