

THE EFFECT OF WHOLE BODY VIBRATION
ON DELAYED-ONSET MUSCLE SORENESS

By

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CHAPTER I

INTRODUCTION

Fitness is defined as the “ability to perform daily tasks vigorously and alertly, with energy left over for enjoying leisure time activities and meeting emergency demands” (President’s Council on Physical Fitness & Sports, 2010). Physical fitness is thought to encompass three major areas of physical activity: 1) flexibility training, 2) cardiorespiratory training, and 3) strength training (Meisler, 2002; Slack, 2006). Combinations of these physical activities have shown to lead to health benefits, and these benefits include improved cardiovascular health, cardiovascular disease prevention, cancer prevention, stress reduction, improved mood, and improved quality of life (Slack, 2006). In addition, physical activity has also demonstrated decreases in blood pressure, cigarette smoking, diabetes, obesity, levels of triglycerides, and an increase in HDL’s (American Heart Association [AHA], 2010).

Several agencies have set forth guidelines for attaining physical fitness and preventing disease (Centers for Disease Control [CDC], 2007; Haskell, et al., 2007). While overall fitness is important in the overall health picture, one of the more prominent issues is the influence of physical activity on chronic disease states (Kraus, 2010). The CDC encourages adults to engage in 30 minutes or more of moderate exercise five days a week or 30 minutes of vigorous exercise 3 days a week to provide health benefits (CDC,

2007), and the Academy of Sports Medicine (ACSM) and the American Heart Association suggest a combination of 30 minutes of moderately intense cardio five days a week or 20 minutes of vigorously intense cardio three days a week with eight to ten strength-training exercises twice a week (Haskell, et al., 2007).

The above prescriptions for health benefits from physical activity include recommendations for exercises involving both aerobic and anaerobic metabolism. Aerobic metabolism is that which requires the presence of oxygen, while anaerobic metabolism does not require the presence of oxygen (Baechle & Earle, 2008). Examples of aerobic exercises are jogging, running, cycling, and swimming. Aerobic exercises are submaximal, steady paced, and enduring in nature (Baechle & Earle, 2008). Anaerobic exercises are those activities in short bouts at high intensities such as resistance training, plyometric training, speed and agility drills, and interval training (Baechle & Earle, 2008). Benefits typically associated with aerobic activity include increased cardiac output, stroke volume, and aerobic power with decreases in resting heart rate and body fat percentage (Baechle & Earle, 2008). Anaerobic activities such as resistance training tend to maintain or increase muscular strength and endurance, muscle mass, bone density, and metabolic rate (Swain & Leutholtz, 2007). However, as an individual begins to increase physical activity, whether it is through a new activity or a simple increase in current activity, caution must be taken to avoid potential problems. Among these problems are dehydration, exhaustion, musculoskeletal injury, and general soreness. Prevention and prompt treatment of these complications is key in maintaining and increasing physical activity levels as these problems may easily lead to further health issues.

Of specific interest is the prevention and treatment of soreness as it applies to muscle during physical activity onset or increase as this is often shown to hinder continued exercise. Individuals typically will experience pain or discomfort approximately 24 hours post-exercise and continuing throughout the next 4-6 days once a new program of physical activity is implemented. This is considered delayed-onset muscle soreness (DOMS) (Armstrong, 1984; Smith, 1992). General disagreement exists regarding the exact cause of DOMS, while a fair consensus remains that this phenomenon may be detrimental to physical activity in a variety of ways. These include compensation for the sore musculature by changing mechanics of activity, decreasing the amount or intensity of physical activity, or even cessation of physical activity. Any of the above mentioned methods of dealing with DOMS may lead to further injury by placing excessive strain on musculature unaccustomed to high levels of intensity, allowing the body to readapt to the inactive state, or potentially allowing the body to become susceptible to disease due to inactivity and weight gain.

Because DOMS is an ailment typically treated at home by those individuals not participating in some form of organized sport, more attention needs to focus on potential methods for decreasing the effects of DOMS in the general population as well as the treatments utilized for those individuals who are involved in organized physical activity. It is unfortunate that the general population must suffer more from the possible effects on health because of the inability to pose successful treatment standardization for DOMS. Therefore, it is the aim of this study to identify the benefits of a potential treatment method for DOMS.

Delayed-onset muscle soreness is frequently assessed through measures of flexibility and power (Micklewright, 2009; Tokmakidis, Kokkinidis, Smilios, & Douda 2003; Zainuddin, Newton, Sacco, & Nosaka 2005). Both flexibility and power are considered components of fitness, and both have shown to be negatively affected by DOMS (Armstrong, 1984; Baechle & Earle, 2008; Carlock et al., 2004; Ebbeling & Clarkson, 1989; MacIntyre, Reid, & McKezie, 1995; Meisler, 2002; Miles & Clarkson, 1994; Peterson, Alvar, & Rhea, 2006; Slack, 2006; Wisloff, Castagna, Helgerud, Jones, & Hoff, 2004). Flexibility is defined as the range of motion about a body joint with static and dynamic components (Baechle & Earle, 2008; Baumgartner, Jackson, Mahar, & Rowe, 2003), while power is defined as “the time rate of doing work” (Power, n.d.).

No treatment methods for DOMS are currently recommended as the gold standard. Currently employed treatments include ice, stretching, non-steroidal-anti-inflammatory drugs (NSAIDS), therapeutic ultrasound, electrical stimulation, massage, exercise, and vibration. Some of these modalities are shown to be useful in more than one arena. More specifically, vibration has shown effectiveness in flexibility and explosive power (Armstrong, Grinnell, & Warren, 2010; Cochrane & Stannard, 2005; Wyon, Guinan, & Hawkey, 2010). Several methods for decreasing DOMS have demonstrated effectiveness through increased flexibility and power measures (Bobbert, Hollander, & Huijing, 1986; Cheung, Hume, & Maxwell, 2003; Wessel & Wan, 1994). One such method used for decreasing DOMS is whole body vibration (WBV). This method employs a platform on which an individual stands and receives energy transfer from the actuator (platform) through forced oscillation (Rittweger, 2010).

Problem Statement

Delayed-onset muscle soreness is an ailment that regularly affects the physically active population (Cleary, Kimura, Sitler, & Kendrick 2002). Therapeutic modalities such as massage, cold or warm whirlpools, contrast baths, ultrasound, and superficial heat are often used to alleviate the symptoms of DOMS; however, no standard treatment protocols currently exist for DOMS (Cleary et al., 2002; Kuligowski, Bagger, Caserotti, & Blanc 1998; Zainuddin et al., 2005).

Purpose of Study

The purpose of this study is to determine the effects of WBV on DOMS through measures of perceived pain, flexibility, and explosive power.

Definition of Terms

Actuator – The source of vibration during vibration therapy. The vibration platform.

Damp – The process of decreasing resonance within the body by reducing the oscillations transmitted from the actuator.

Delayed-Onset Muscle Soreness – The phenomenon typically occurring 24-48 hours after bouts of eccentric exercise and presenting as a dull ache within the muscle upon movement or palpation.

Flexibility – The range of motion about a joint.

Numeric Rating Scale – The pain measurement scale that consists of a verbal indication of pain level corresponding to a number; typically the scale is read from 0-10 or 0-100.

Power – The time rate of doing work (Power, n.d.).

Resonance – The amount of oscillation within the body as a result of vibration application from the actuator.

Sit-and-Reach Test – A frequently used method for evaluating lower back and hamstring flexibility.

Verbal Rating Scale – The pain measurement scale that consists of adjectives corresponding to pain level; adjectives are assigned numbers to simplify the scale.

Vertical Jump – The test often used to measure anaerobic power in the lower extremity.

Visual Analogue Scale – The pain measurement scale that consists of a 10 cm line on which the patient marks the pain level with a writing utensil.

Whole-Body Vibration – The transfer of vibration energy from an actuator (vibration platform) to a resonator (body) through forced oscillation.

Assumptions

- It is assumed that none of the participants will be participating in other conditioning programs during data collection.
- It is assumed that all participants will have cognitive function that allows for appropriate responses to the Visual Analog Scale (VAS).
- It is assumed that all participants will answer honestly and appropriately on the Health History Questionnaire.
- It is assumed that all participants will respond honestly to the VAS.

Significance of Study

This study has the potential to provide rationale for a new treatment of DOMS. If whole body vibration significantly decreases the pain perceived in DOMS and an improvement in function, clinicians will have another alternative for treating this ailment. This new treatment then may influence muscle performance in those physically active individuals experiencing symptoms of DOMS. It may also then be utilized by individuals

in the sports medicine and strength and conditioning arenas as their athletes begin conditioning programs and return to play activities.

Limitations of Study

- Findings from this study cannot be generalized as the participants in this study are from a regional area.
- Findings from this study cannot be generalized as the participants in this study are college-aged individuals.
- Pain is subjective in nature and is difficult to quantify on occasion.
- Participants may not always report honestly when asked to assess their pain rating.
- Participants may not always report honestly when asked to refrain from treatment methods outside those incorporated into the study.
- The Visual Analog Scale is rated as demonstrating moderate concurrent validity when compared with other scales.
- Scores from the Visual Analog Scale may not always be normally distributed. In such cases nonparametric statistical tests are recommended.
- The percentage of body weight used to induce DOMS may not have been large enough to induce DOMS for some participants.

Delimitations of Study

- Participants will be recruited from a public urban University in the Southcentral United States.
- Participants will be considered healthy individuals with no known bone or muscle disease.

- Participants will be free of injury within the last 6 months and free of any surgical procedures in the last 12 months.

Hypotheses

Pain:

H₀: No difference exists between the treadmill walking and whole body vibration groups on post-test VAS scores.

H₁: A difference exists between the treadmill walking and whole body vibration groups on post-test VAS scores.

Range of Motion:

H₀: No difference exists between the treadmill walking and whole body vibration groups on post-test sit-and-reach scores.

H₂: A difference exists between the treadmill walking and whole body vibration groups on post-test sit-and-reach scores.

Vertical Jump:

H₀: No difference exists between the treadmill walking and whole body vibration groups on post-test vertical jump scores.

H₃: A difference exists between the treadmill walking and whole body vibration groups on post-test vertical jump scores.

CHAPTER II

REVIEW OF LITERATURE

A review of the literature reveals a variety of recommendations for treating delayed-onset muscle soreness (DOMS). Studies have indicated that DOMS may be treated and actually decreased by utilizing methods such as passive stretching, massage, acupuncture, cold water immersion, hot water immersion, contrast water immersion, ultrasound, electrical stimulation, compression, exercise, and administering non-steroidal anti-inflammatory drugs such as ibuprofen (Hubscher, Vogt, Bernhorster, Rosenhagen, & Banzer, 2008; Kuligowski et al., 1998; Lund, Vestergaard-Pulsen, Kanstrup, Sejrsen, 1998; Micklewright, 2009; Rahnama, Lees, & Reilly, 2006; Tokmakidis et al., 2003; Vaile, Halson, Gill, & Dawson, 2008; Zainuddin et al., 2005). Other literature claims the best treatment for delayed-onset muscle soreness may actually be prevention rather than an after-the-fact modality as no current treatment is classified as “the standard” (Cleary et al., 2002; Perrey, Bringard, Racinais, Puchaux, & Belluye, 2008). To date, only one study has explored the use of whole body vibration (WBV) as a treatment for DOMS (Rhea, Bunker, Marin, & Lunt, 2009). This leaves a large gap in both the recommendations for DOMS treatment and the varied uses of WBV. The following two sections will attempt to describe in detail the phenomenon of delayed-onset muscle soreness and the uses of whole body vibration, respectively. The third, fourth, and fifth sections will explore the

use of pain rating scales, flexibility measures, and strength and power measures in research.

Delayed-Onset Muscle Soreness (DOMS)

Delayed-onset muscle soreness is commonly understood to occur within 24-48 hours after bouts of eccentric exercise (Aytar et al., 2008; Clarkson, Nosaka, & Braun, 1992; Gulick & Kimura, 1996; MacIntyre et al., 1995; Miles & Clarkson, 1994; Nosaka, Newton, & Sacco, 2002; Perrey et al., 2008). This phenomenon presents as a dull ache within the muscle tissue upon movement or palpation. Other symptoms of DOMS include stiffness, loss of muscle strength, decreased range of motion (ROM), swelling, and decreased proprioception (Armstrong, 1984; Ebbeling & Clarkson, 1989; MacIntyre et al., 1995; Miles & Clarkson, 1994). These symptoms have been documented to subside within 3-10 days post-exercise (Cheung et al., 2003; Smith, 1991).

Theories

A variety of theories are documented in the development of DOMS. These include lactic acid, muscle spasm, connective tissue damage, muscle damage, inflammation, and the enzyme efflux theory (Armstrong, 1984; Cleak & Eston, 1992; Connolly, Sayers, & McHugh, 2003; Mizumura, 2008). Several of these theories, however, are refuted by research. The lactic acid theory holds that the lactic acid build-up within the exercised muscle causes delayed-onset muscle soreness. However, lactic acid levels have been shown to return to pre-exercise levels within one hour of exercise. Therefore, this theory does not hold to causing DOMS (Mizumura, 2008). This theory is more suited to explain the acute pain experienced immediately following intense exercise (Mizumura, 2008).

The spasm theory is based on resting muscle activity after eccentric exercise (Jones, Newham, & Clarkson, 1987). The spasm was thought to compress blood vessels and ultimately lead to ischemia (Mizumura, 2008). This theory lacks merit based on the controversial findings related to electromyographic (EMG) activity (Jones et al., 1987).

The connective tissue damage theory examines the connective tissue surrounding muscle fiber bundles. A distinction drawn between muscle fiber types indicates fast-twitch muscle fibers are more susceptible to injury and soreness than slow-twitch muscle fibers. Measures of hydroxyproline (HP) and hydroxylysine (HL) levels in urine samples demonstrate either degradation or synthesis of collagen. While these measures indicate some reaction is occurring regarding the collagen, it leaves uncertainty in the exact rationale for HP and HL in the urine. This uncertainty leads researchers to stray from the connective tissue damage theory (Cheung et al., 2003).

Contractile component disruption led to the muscle damage theory (Friden & Lieber, 1992; Friden, Sjostrom, & Ekblom, 1983). Increased tension per unit is responsible for the damage to the contractile component. This increased tension per unit is a direct effect of the reduction in active motor units during eccentric exercise as compared to concentric exercise (Armstrong, 1984). DOMS is often associated with muscle damage, but lines must be drawn to separate the two. While DOMS is a symptom of muscle damage, it cannot be assumed muscle damage is present with every case of DOMS (Nosaka et al., 2002).

Edema formation and infiltration of inflammatory cells provide the basis for the inflammation theory (Evans et al., 1986; Francis & Hoobler, 1987; Smith, 1991). Monocytes and neutrophils are attracted to the injured area as the accumulation of

bradykinin, histamine, and prostaglandins increase (Hasson et al., 1993). Inflammatory cell filtration does not seem to coincide well with peak soreness (Gulick & Kimura, 1996; Jones, Newham, Round, & Tolfree, 1986; Lightfoot, Char, McDermott, & Goya, 1997). Only peak edema production has been shown to coincide with peak soreness (Gulick & Kimura, 1996). This theory remains controversial, and therefore, some authors choose to refer to this theory as the Tissue Fluid Theory rather than the inflammation theory (Gulick & Kimura, 1996).

The enzyme efflux theory operates on the idea that calcium from the damaged sarcolemma accumulates in the muscle tissue thus activating proteases and phospholipases to produce leukotrienes and prostaglandins in the injured area (Armstrong, 1990; Armstrong, 1984). The release of these enzymes causes a chemical stimulation of pain nerve endings that is perceived as muscle soreness (Gulick & Kimura, 1996).

None of the theories mentioned above have been shown to stand alone in the explanation of delayed-onset muscle soreness. Many researchers have now begun to think of DOMS as a sequence of events that incorporates ideas from each theory as a component of the overall phenomenon (Armstrong, 1984; Smith, 1991).

Consequences

Individuals suffering from delayed-onset muscle soreness may experience variations to muscle function and joint mechanics (Rowlands, Eston, & Tilzey, 2001). Impairments commonly experienced include decreases in range of motion and strength along with changes to muscle firing patterns as documented through electromyography (Cheung et al., 2003). These changes sometimes go unnoticed as individuals attempt to continue participation in activity (Goff, Hamill, & Clarkson, 1998; Saxton et al., 1995).

At this point, individuals who subconsciously make these adjustments are more susceptible to injury (Saxton et al., 1995). Thus, DOMS may ultimately play a role in the amount and severity of sustained injuries.

Strength deficits seem to be most apparent within the eccentric contractions as compared to the isometric and concentric contractions of the same muscles (Hasson et al., 1993; Nosaka & Clarkson, 1996). The decline in eccentric strength is also shown to last longer than isometric and concentric reductions (Ebbeling & Clarkson, 1989). Eccentric strength returns to baseline after 8-10 days, while only four days is necessary for isometric and concentric strength measures to return to baseline (Ebbeling & Clarkson, 1989).

Muscle coordination may also decrease in the presence of DOMS. Changes occurring in the recruitment patterns of muscle have the potential to be detrimental to coordination (Edgerton, Wolf, Levendowski, & Roy, 1996). These changes are the results of electromechanical delays and alterations in the temporal sequencing of muscles. Delayed-onset muscle soreness is thought to play a role in these alterations as the changes are attributed to impaired muscle conductivity, contractility, or elasticity or increases in muscle temperature (Miles, Ives, & Vincent, 1997; Zhou, 1996; Zhou, Carey, Snow, Lawson, & Morrison, 1998).

The risk of injury is increased when DOMS is present. A lack of full range of motion may lead to the inability to efficiently absorb the shock that comes from physical activity (Cheung et al., 2003; Hamill, Freedson, Clarkson, & Braun, 1991). Modifications to mechanical motion may increase strain placed on soft tissue structures. Reduced force output may signal compensatory recruitment of muscles, thus leading to unaccustomed

stress on musculature (Saxton et al., 1995). Variations in strength ratios may also cause excessive strain on unaccustomed musculature (Orchard, Marsden, Lord, & Garlick, 1997).

Treatment

Treatments are divided into two categories: prophylactic and therapeutic. Prophylactic treatments are used as preventative measures while therapeutic treatments are those occurring after injury. Several treatments for delayed-onset muscle soreness have been explored. These include cryotherapy, stretching, anti-inflammatory drugs, ultrasound, electrical stimulation, massage, compression, and exercise (Cheung et al., 2003).

A standard treatment protocol for soft tissue injuries has been R.I.C.E. (rest, ice, compression, elevation) (Cheung et al., 2003). This protocol incorporates two of the above listed strategies (cryotherapy and compression) for decreasing the effects of DOMS. Cryotherapy has been shown to be effective in decreasing pain and swelling in muscle tissue (Swenson, Sward, & Karlsson, 1996). However, in relation to DOMS, the application of ice to an injured area has only shown an analgesic effect (Cheung et al., 2003). Cryotherapy has not been shown to influence isometric or isokinetic torque production in the presence of DOMS (Paddon-Jones & Quigley, 1997). The use of compression as a treatment to DOMS has been relatively unexplored. Kraemer et al. (2001) found the use of compression to be effective as a therapeutic treatment for delayed-onset muscle soreness. However, this one study alone is not enough to substantiate the benefits of using compression for treating DOMS.

Stretching is often recommended as both a prophylactic and therapeutic means of decreasing the effects of DOMS (Wessel & Wan, 1994). The stretch is thought to counteract the muscle spasm associated with the muscle spasm theory while also dispersing the edema formed after tissue damage (Bobbert et al., 1986; Wessel & Wan, 1994). While these ideas seem to provide a rationale for the use of stretching as a treatment for DOMS, studies have shown stretching to exhibit no success in preventing DOMS (High & Howley, 1989; Johansson, Lindstrom, Sundelin, & Lindstrom, 1999; Smith et al., 1993; Wessel & Wan, 1994).

A likely treatment for DOMS based on the inflammation theory would be the use of anti-inflammatory drugs. However, when exploring the treatment of DOMS with non-steroidal anti-inflammatory drugs (NSAIDS) it is important to note differences in administration time, type of drug, and dosage (Gulick, Kimura, Sitler, Paolone, & Kelly, 1996; Hasson et al., 1993). Differences in these parameters have demonstrated varied findings in the literature (Donnelly, Maughan, & Whiting, 1990; Francis & Hoobler, 1987; Gulick & Kimura, 1996; Gulick et al., 1996; Hasson et al., 1993; Hasson, Wible, Reich, Barnes, & Williams, 1992).

Other therapeutic modalities such as ultrasound and electrical stimulation are sometimes recommended for the treatment of DOMS (Allen, Mattacola, & Perrin, 1999; Butterfield et al., 1997; Denegar, Perrin, Rogol, & Rutt, 1989; Hasson, Mundrof, & Barnes, 1989). Ultrasound is believed to increase relief of DOMS through increasing tissue temperature and blood flow, thus assisting the removal of inflammation in the area. This hypothesis has been tested with varied results. Hasson et al. (1989) found an ultrasound led to a significant decrease in muscle soreness at 48 hours post-exercise,

while Ciccone, Leggin, & Callamaro (1991) found ultrasound led to an increase in muscle soreness at 48 hours post-exercise. Different types of electrical stimulation have been used to treat DOMS. Currently, only transcutaneous electrical nerve stimulation (TENS) and interferential current have shown decreases pain perception related to DOMS (Denegar & Huff, 1988).

Reports vary on the efficacy of massage on delayed-onset muscle soreness. An increase in blood flow is believed to contribute to a reduction in local inflammation, thus decreasing the sensations associated with DOMS (Cheung et al., 2003). Increases in blood flow after massage have been reported by some researchers, while others report no significant increase in blood flow was identified (Carafelli & Flint, 1992; Hovind & Nielsen, 1974; Tiidus, 1997). These differences may be attributed to the variety of massage techniques employed in the literature as well as the differences existing from therapist to therapist utilizing the same technique (Ernst, 1998). More standardization is necessary in developing massage protocols in the treatment of DOMS.

Exercise has been shown to be one of the most beneficial treatments in reducing the signs and symptoms of DOMS (Armstrong, 1984). Problems commonly encountered using exercise as a treatment for DOMS include the return of pain sensation quickly after exercise ends and difficulty performing exercise tasks due to limitations from DOMS (Smith, 1992). Literature shows inconsistencies in utilizing exercise as a treatment for delayed-onset muscle soreness (Donnelly, Clarkson, & Maughan, 1992; Gulick et al., 1996; Hasson, Williams, & Signorile, 1989; Weber, Servedio, & Woodall, 1994). These differences, however, may be attributed to non-standardization of exercise protocols (Gulick et al., 1996).

Several methods for identifying the cause of delayed-onset muscle soreness and treating the signs and symptoms of it have been established. Many of the treatments are based on the science behind the proposed theories of occurrence but lack evidence to support their use as evidence based practices. It is important also to note that the lack of understanding for exactly how DOMS occurs may directly affect the lack of standardized treatment protocols.

Vibration

Issurin (2005) identifies two major uses of vibration in sport: vibratory massage (VM) and vibration training (VT). VM has been studied in relation to sport with two major goals at hand: “1) to activate restorative processes and thereby enhance athletes’ adaptability to higher training workloads, and 2) to increase athletes’ working potential and their readiness for forthcoming competitive or training efforts” (Issurin, 2005). VT focused on “1) physical exercises with local vibration, and 2) motor tasks performed under vibration of the whole body” (Issurin, 2005). Vibration exercise as described by Rittweger (2010) is the transfer of energy from an actuator to a resonator through forced oscillation. Whole body vibration is the most commonly practiced form of vibration exercise and is considered to be a relatively new technique (Hand, Verscheure, & Osternig, 2009; Rittweger, 2010).

Two modes of vibration transmission exist within whole body vibration: 1) synchronous, and 2) side-alternating (Rittweger, 2010). The synchronous vibration transmission elicits the vibration to both feet simultaneously (Figure I) (Rittweger, 2010). The side-alternating mode elicits the vibration in a manner “so that the right foot is lowest when the left foot is highest” (Figure II) (Rittweger, 2010). The side-alternating

mode is suspected to also elicit a rotational movement about the hip and lumbo-sacral joints (Rittweger, Schiessl, & Felsenberg, 2001).



Figure I. Synchronous Vibration Platform. Adapted from Rittweger 2010.

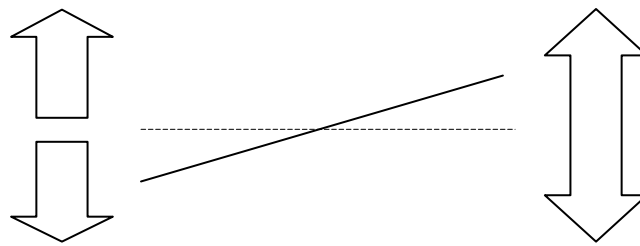


Figure II. Side-Alternating Vibration Platform. Adapted from Rittweger 2010.

Research has shown that vibration exercise causes acute physiological effects as well as adaptive and training effects. These effects include elongation of musculature (Cochrane, Loram, Stannard, & Rittweger, 2009), hormonal changes (Bosco et al., 2000; Di Loreto et al., 2004; Goto & Takamatsu, 2005; Kvorning, Bagger, Caserotti, & Madsen, 2006), and increases in the stretch reflex (Shinohara, Moritz, Pascoe, & Enoka, 2005; van Boxtel, 1986), EMG activity (Abercromby et al., 2007; Cardinale & Lim, 2003; Seidel, 1988), muscular energy metabolism (Rittweger, Just, Kautzch, Reeg, &

Felsenberg, 2002; Rittweger et al., 2001), intramuscular temperature (Cochrane, Stannard, Sargeant, & Rittweger, 2008), muscle power (Bautmans, van Hees, Lemper, Mets, 2005; Roelants, Delecluse, Goris, & Verschueren, 2004), joint stability (Melnik, Kofler, Faist, Hodapp, & Gollhofer, 2008), flexibility (Cochrane & Stannard, 2005; Kinser et al., 2008), and bone strength (Gusi, Raimundo, & Leal, 2006; Verschueren et al., 2004).

At the forefront of research regarding vibration as a training method is the idea that vibration training may be used independently or in conjunction with resistance training (Bautmans et al., 2005; Delecluse, Roelants, & Verschueren, 2003; Hand et al., 2009; Roelants et al., 2004). While similarities have been shown between vibration training and resistance training, one must take into consideration the populations at hand. The most significant gains above a resistance trained group by a vibration trained group are present in an elderly population typically considered more likely classified as frail (Bautmans et al., 2005; Bruyere et al., 2005). Vibration training has shown comparable increases to resistance training in a generalized population, however, it has not been shown to supersede gains in resistance training (Delecluse et al., 2003; Hand et al., 2009; Roelants et al., 2004). Acute improvements have also been shown in flexibility while using vibration training (Cochrane & Stannard, 2005; Kinser et al., 2008). Combining the ideas of gains in strength, power, and flexibility through vibration training, we can begin to focus more attention on using vibration training as a means of rehabilitation.

A majority of research involving the clinical application of vibration has been focused on the geriatric population. Vibration training has shown improvements in chair-rising time, timed up-and-go tests, leg extension power, postural sway, and overall self-

assessed quality of life in regards to the elderly population (Bautmans et al., 2005; Bruyere et al., 2005; Runge, Rehfeld, & Resnicek, 2000; Torvinen et al., 2002). Vibration may also be used in a therapy context with regards to treating back pain, fibromyalgia, Parkinson's disease, stroke patients, multiple sclerosis, cerebral palsy, spina bifida, type-2 diabetes, and orthopaedic injuries (Alentorn-Geli, Padilla, Moras, Lazaro, & Fernandez-Sola, 2008; Baum, Votteler, & Schiab, 2007; Haas, Turbanski, Kessler, & Schmidtbleicher, 2006; Iwamoto, Takeda, Sato, & Uzawa, 2005; Melnyk et al., 2008; Moezy, Olyaei, Hadian, Razi, & Faghihzadeh, 2008; Rittweger et al., 2002; Schuhfried, Mittermaier, Jovanovic, Pieber, & Paternostro-Sluga, 2005; Semler, Fricke, Vezyroglou, Stark, & Schoenau, 2007; Turbanski, Haas, Schmidtbleicher, Friedrich, & Duisberg, 2005; van Nes, Geurts, Hendricks, & Duysens, 2004).

Many of the instances above indicate the use of vibration training as a method to improve balance in those individuals experiencing difficulty in standing (Sato, Honda, Iwamoto, Kanoko, & Satoh, 2005; Turbanski et al., 2005; van Nes et al., 2004). While this application is important in the rehabilitation of specific diseases and injuries, it is also important to go about the rehabilitation as pain-free as possible (Houglum, 2010). In utilizing vibration as a therapeutic modality to decrease pain, the gate control theory of pain is employed. The gate control theory of pain states that fast conducting somatosensory afferents can block poorly myelinated nociceptives at the spinal level (Melzack & Wall, 1996). Essentially, stimulation of the A β fibers causes the substantia gelatinosa in the dorsal horn of the spinal cord to close the gate to the pain impulses as they are sent on the A δ and C fibers from the first order neurons to the second order neurons. The application of this theory with respect to treating orthopaedic injuries, acute

and chronic pain, diseases such as fibromyalgia, and potentially delayed-onset muscle soreness may in fact be enhanced with the use of vibration training.

Safety Concerns

Traditionally vibration has been associated with causing pain, often in the back (Bongers, Boshuizen, Hulshof, & Koemeester, 1988; Muzammil, Siddiqui, & Hasan, 2004), rather than decreasing pain. Studies have shown back pain, to increase with occupational whole-body vibration, specifically those individuals operating large machinery such as trucks and tractors (Bongers et al., 1988; Bovenzi, 1996; Bovenzi & Betta, 1994; Muzammil et al., 2004). In an effort to decrease the health complications caused by whole body vibration, the International Organization for Standardization (ISO) developed guidelines for whole body vibration exposure (ISO, 1997). ISO 2631-1 (1997) limits whole body vibration in three manners: 1) comfort, 2) performance proficiency, and 3) safety. For purposes of exercise and rehabilitation, safety is the major concern of whole body vibration exposure. The limits were established by the ISO based on data acquired from vibration application through the buttocks of aircraft pilots and drivers (ISO, 1997). Therefore, it is impossible to apply these limits in a straightforward manner to exercise and rehabilitation as these activities involve vibration applied through the extremities where a damp effect may be found (Wakeling, Nigg, & Rozitis, 2002). This damp effect essentially limits the amount of vibration that is transmitted through the body by allowing the muscles to produce a friction resistance to the resonance.

In order to prevent resonance within the body regardless of the damping effect, frequencies below 5 Hz should be avoided, while frequencies below 20 Hz should be used with extreme caution (Rittweger, 2010). Changes in posture and the use of side-

alternating vibration are also recommended to decrease the amount of resonance within the body and transmission of vibration to the trunk and head where the potential is greater for injury (Rittweger, 2010).

Pain Rating Scales

Identifying the level of pain associated with disease, illness, and injury is important as clinicians work to incorporate new treatment protocols. Pain has varying degrees of complexity including intensity as it is affected by the meaning of the pain and the expected duration (Turk & Melzack, 1992).

The Visual Analogue Scale (VAS) is a pain rating scale represented by a 10-cm line with the end points marked by pain descriptions such as “No Pain” and “Severe Pain” (Holdgate, Asha, Craig, & Thompson, 2003; Prentice, 2009; Williamson & Hoggart, 2005). The participant is asked to demonstrate his or her pain level by marking on the line the point between these two descriptions that corresponds to the pain felt (Holdgate et al., 2003; Prentice, 2009; Williamson & Hoggart, 2005).

The Verbal Rating Scale (VRS), a pain scale consisting of adjectives, and the Numerical Rating Scale (NRS), a pain scale consisting of numbers corresponding to pain level, are often compared to the VAS (Cork et al., 2004; Holdgate et al., 2003; Larroy, 2002; Lund et al., 2005; Prentice, 2009; Williamson & Hoggart, 2005). These comparisons have shown test-retest reliability to be higher with the VAS than the other two scales, however, the VRS has been deemed to provide reliability for scientific information (Lara-Munoz, De Leon, Feinstein, Puente, & Wells, 2004).

While all three scales listed above have been deemed reliable and appropriate for use in clinical practice, none of the scales are interchangeable; therefore, only one scale

can be utilized at a time to measure pain and make comparisons of initial pain and post-treatment pain (Lund et al., 2005). When choosing which scale to utilize, sensitivity to change must also be taken into account (Williamson & Hoggart, 2005). The VAS and NRS scales demonstrate better sensitivity to changes in pain (Jamison et al., 2002; Jensen, Karoly, & Braver, 1986).

Administration of both the VAS and the NRS is considered a rather quick assessment (Cork et al., 2004; Holdgate et al., 2003; Kahl & Cleland, 2005; Larroy, 2002; Lund et al., 2005; Williamson & Hoggart, 2005). Studies have shown administration of the NRS scale to be more convenient than the VAS (Holdgate et al., 2003; Larroy, 2002); however, the VAS is commonly used in assessment of pain for research purposes as well as in emergency situations (Holdgate et al., 2003; Larroy, 2002). The method of administration of the VAS continues to undergo debate. Reading patterns of the population for which the test is administered should be taken into consideration prior to administration (Williamson & Hoggart, 2005). For example, a horizontal orientation may be better suited for an English reading population than for a Chinese reading population and vice versa (Aun, Lam, & Collett, 1986; Scott & Huskisson, 1979). The use of the VAS for repeated measures also remains controversial (Holdgate et al., 2003; Kahl & Cleland, 2005; Lund et al., 2005; Williamson & Hoggart, 2005). Because the VAS represents pain as a continuum, Lund et al. (2005) recommends the data should be analyzed as ordinal data. This allows the possibility of over- or under estimations of perceived pain. Kahl and Cleland (2005) contend the data obtained through use of the VAS classifies as ratio data and may be analyzed using parametric statistics provided the data passes the normality test (Williamson & Hoggart, 2005).

Flexibility Measures

Flexibility is defined as the range of motion about a body joint with static and dynamic components (Baechle & Earle, 2008; Baumgartner et al., 2003). The idea of static flexibility is based on the application of an outside force with no muscular contraction used to increase range of motion. Dynamic flexibility requires active movements and no outside force to improve range of motion (Baechle & Earle, 2008).

Flexibility is identified as a component of fitness and is often measured using manual and electric goniometers and the sit-and-reach box (Baechle & Earle, 2008; Meisler, 2002; Slack, 2006). Normative data exist regarding flexibility by age and sex, however, other factors may affect flexibility (Hoffman, 2006). These other factors include joint structure, connective tissue, resistance training with limited range of motion, muscle bulk, and activity level (Baechle & Earle, 2008).

Measurement of flexibility with regard to fitness is commonly associated with the lower back and hamstrings (Baumgartner et al., 2003). The sit-and-reach test is frequently used as the method for evaluating lower back and hamstring flexibility, especially in instances of large numbers of participants to be tested (Minarro, Andujar, & Garcia, 2009), but it should be noted that this test is a better measure of hamstring flexibility than lower back flexibility (Baumgartner et al., 2003). A close relative of the sit-and-reach test, the FITNESSGRAM[®] back saver sit-and-reach test may also be used to assess hamstring flexibility (Baumgartner et al., 2003; Hartman & Looney, 2003; Martin, Jackson, Morrow, & Liemohn, 1998; Minarro et al., 2009). Ideally, the back-saver sit-and-reach test will protect the lower back against undo flexion (Minarro et al, 2009).

Studies have shown both the traditional sit-and-reach test and the back-saver sit-and-reach test restrict spinal flexion. Both of these methods show moderate validity for measuring hamstring flexibility, but no definitive study has shown validity in measuring low back flexibility through either of these methods (Minarro et al., 2009). Minarro et al. (2009) suggest using the back-saver sit-and-reach test when independent measures of left and right hamstring flexibility is necessary and using the traditional sit-and-reach test if independent measures are not necessary.

While methods of measuring flexibility are extremely important to observing fitness levels, improving flexibility is also an important point of discussion. Several methods for enhancing flexibility have been documented through the literature (Cochrane & Stannard, 2005; Draper, Andeson, Schulthies, & Ricard, 1998; Kinser et al., 2008; Wallin, Ekblom, Grahn, & Nordenborg, 1985). These techniques include stretching, therapeutic ultrasound, and whole-body vibration (Cochrane & Stannard, 2005; Draper et al., 1998; Kinser et al., 2008; Wallin et al., 1985).

Strength and Power Measures

Strength and power are two very closely related measures of fitness (Carlock et al., 2004; Peterson et al., 2006; Wisloff et al., 2004). Strength is defined as “the maximal force that a muscle or muscle group can generate at a specified velocity” (Knuttgen & Kraemer, 1987), while power is defined as “the time rate of doing work” (Power, n.d.). Work is observed as the product of the force applied to an object and the distance the object moves in the direction of the applied force. A close look at the following equations used in calculating strength and power reveals the relationship in a mathematical sense. Force is determined by mathematical equation (EQ #1).

F = Force

M = Mass

A = Acceleration

$$\mathbf{F = M \times A} \tag{1}$$

Work is determined by mathematical equation (EQ #2).

W = Work

F = Force

D = Distance

$$\mathbf{W = F \times D} \tag{2}$$

Power is determined by mathematical equation (EQ #3).

P = Power

W = Work

T = Time

$$\mathbf{P = W \div T} \tag{3}$$

Research has shown correlations between strength and power (Carlock et al., 2004; Peterson et al., 2006; Wisloff et al., 2004), thus indicating a rationale for resistance training to improve power. As previously discussed, research also shows that whole body vibration may be used in conjunction with or independent of resistance training (Bautmans et al., 2005; Delecluse et al., 2003; Hand et al., 2009; Roelants et al., 2004). Accordingly, whole body vibration should be included as a method of increasing power. Research has demonstrated effectiveness in this method of increasing power output through the vertical jump measurement (Armstrong et al., 2010; Wyon et al., 2010).

Two speed categories exist in the discussion of muscular strength and power. Maximum muscular strength is assessed as low-speed strength, while anaerobic or maximum muscular power is assessed as high-speed strength. Maximum muscular power or anaerobic power is associated with tests that are very short in duration such as the power clean, snatch, push jerk, vertical jump, and staircase sprinting (Baechle & Earle, 2008).

As the vertical jump requires less of a learning curve and is somewhat safer than the other methods it is often used in research to assess power (Baechle & Earle, 2008; Leard et al., 2007). Several methods exist for assessing vertical jump height. This method includes a video technique in which the jump is filmed, and the displacement at the body's center of gravity is measured (Aragon-Vargas, 2000). While this method is considered highly valid, it is cost-prohibitive due to the expensive equipment required for the motion analysis (Leard et al., 2007). Another method commonly used is the jump and reach test (Leard et al., 2007). These methods may utilize a wall and chalk or a manufactured device (Baechle & Earle, 2008; Leard et al., 2007). One of the common jump and reach devices is the Vertec (Vertec Sports Imports, Hilliard, OH). The jump and reach method measures the distance between the standing reach measure and the highest displaced swivel vane on the Vertec or the highest point of contact with the wall and chalk method (Baechle & Earle, 2008; Klavara, 2000). Contact mats are also used as a method to measure vertical jump height (Leard et al., 2007). This method uses a kinematic equation to calculate jump height based on flight time (Leard et al., 2007). While stronger correlations are demonstrated between the video technique and the

contact mat, the Vertec measurement system remains a valid method for assessing vertical jump height (Leard et al., 2007).

Summary

The effects of DOMS are commonly felt within 24-48 hours after eccentric exercise. Several theories currently exist to explain the development of DOMS with no one theory being accepted as the standard explanation. As each of these theories operate on different physiological changes, several different methods for treating the signs and symptoms of DOMS have emerged with no gold standard of treatment identified.

WBV has been utilized to elicit increases in training workload, working potential, and competitive efforts. While DOMS has shown detrimental effects on measures of flexibility and power, WBV has been shown to improve these measures. Thus, the use of WBV may indeed show to provide relief from signs and symptoms of DOMS. These signs and symptoms include pain ratings, flexibility, and power measures. Pain is rated using a variety of scales. These scales include the VAS, VRS, and NRS. The VAS is often used to evaluate pain based on its ease of use and sensitivity to changes in pain. Flexibility is often measured through the use of goniometers and the sit-and-reach box. The sit-and-reach box is many times chosen over the goniometric measures because of the ease of use and the time commitment to goniometric measures. Maximum muscular power is often measured by tests such as the power clean, push jerk, vertical jump, and staircase sprinting. The vertical jump is often used because it requires less of a learning curve and is safer than the other methods of measuring maximum muscular power.

This review of literature leads us to rationale for exploring the effects of WBV on pain ratings, flexibility, and power as they relate to DOMS and the role each plays in overall fitness.

CHAPTER III

METHODOLOGY

The primary purpose of this study is to identify the effect of whole body vibration on delayed-onset muscle soreness (DOMS). The secondary purpose of this study is the effect of vibration on flexibility and power measures associated with DOMS. This treatment has the potential to provide an alternative treatment for DOMS than those commonly used in clinical settings. This section identifies methods for participant selection as well as methods used for data collection and interpretation.

Research Design

This study was designed as a quantitative investigation of repeated measures on three dependent variables. Data were collected in the form of pre-treatment and post-treatment scores on the Visual Analog Scale as well as pre-treatment and post-treatment scores in the sit-and-reach test and vertical jump.

Participants

Participants for this study were twenty college-aged (20.85 ± 1.81 years) volunteers ($N = 20$) recruited from a regional university in the Southcentral United States. The volunteers consisted of ten healthy males ($n = 10$) and ten healthy females ($n = 10$) currently enrolled at the university. Upon completion of data collection, three participants

were deemed as outliers and were subsequently excluded from data analysis. Those remaining participants (8 male; 9 female) demonstrated mean heights and weights of 67.68 ± 4.01 in (171.19 ± 10.19 cm) and 174.15 ± 40.88 lbs (79.16 ± 18.58 kg).

Descriptive statistics for the participants are presented in Table 1.

	N	Mean	Std. Deviation
Age (years)	17	20.88	1.93
Height (cm)	17	171.19	10.19
Weight (kg)	17	79.16	18.58

Table 1. Descriptive Statistics

Instruments

Health history questionnaire – A health history questionnaire (Appendix B) was used to identify any exclusionary criteria to establish health status for participation.

Pain rating scale – A Visual Analog Scale (Appendix C) was used to measure perceived pain in the hamstrings. Participants were asked to place a vertical line on a 10 cm horizontal line to indicate their level of perceived pain.

Sit-and-reach measurement – The Acuflex[®] I (Novel Products, Inc., Rockton, IL) sit-and-reach flexibility tester was used to identify hamstring and low back range of motion. Participants sat with the feet flat against the Acuflex[®] I (Novel Products, Inc., Rockton, IL). The participants reached forward with both hands as far as possible while the examiner recorded the measurement. An average of three trials was recorded (Baechle & Earle, 2008).

Vertical jump measurement – The Vertec (Vertec Sports Imports, Hilliard, OH) is commonly used to assess vertical jump. The bottom vane of the unit is used to assess the standing touch height. Participants stood with the dominant arm lifted upward to

determine the standing touch height. The participant was then instructed to perform a vertical jump with no step. The best of three trials was recorded (Baechle & Earle, 2008).

Whole body vibration system – Treatments were administered to the participants selected to the vibration treatment group via the VibraTrim VT100[®] (VibraTrim, LLC, Gig Harbor, WA).

Controlled walking – Participants not receiving the whole body vibration treatment walked 3.5 -3.7 mph (1.56-1.65 m/s) on the Woodway Desmo (Woodway USA, Waukesah, WI) treadmill.

Procedure

Participants reported to five (5) data collection sessions over the span of five (5) days. Upon arrival to the first data collection, participants were asked to read and sign a consent form (Appendix A). If the participant chose to participate, he or she was then asked to complete a health history questionnaire in order to determine eligibility for the research.

A certified athletic trainer was present at testing. The certified athletic trainer reviewed the health history questionnaire and determined eligibility for participation. Potential participants were excluded if:

- 1) they reported any injury to the upper or lower extremity, the back, or the abdominals within the past 6 months that held them from normal activities of daily living;
- 2) they reported any surgical procedure within the past 12 months that held them from normal activities of daily living for more than one (1) month; or
- 3) they reported any neurological issues.

Volunteers who successfully passed the health history questionnaire had height and weight measured followed by an assessment of their baseline sit-and-reach test score and vertical jump height. They were then randomly assigned into the treatment or control group. Participants were asked to perform three sets of 10 lunges while holding dumbbells. The weight of the dumbbells was determined for each individual based on his or her weight measures. Approximately 12% to 18% of total body weight was used to identify the weight of each dumbbell. For example a 170 lb (77.27 kg) male would have executed three sets of 10 lunges with two 20 lb (9.09 kg) or 30 lb (13.63 kg) dumbbells. This exercise induced delayed onset muscle soreness in the legs and buttocks. All participants immediately reported Visual Analog Scale (VAS) pain measures and were again assessed for sit-and-reach scores and vertical jump height. Those participants assigned to the treatment group then spent 10 minutes on the VibraTrim VT100[®] (VibraTrim, LLC, Gig Harbor, WA). Speed was adjusted on the VibraTrim VT100[®] as the timer counted down from 10 minutes (Appendix D). Participants in the control group then spent 10 minutes walking at a pace between 3.5 mph and 3.7 mph (1.56 and 1.65 m/s) on a Woodway Desmo (Woodway USA, Waukesah, WI) treadmill. Speeds for the treadmill differed for each participant depending upon leg length and comfort. Participants were instructed to choose a speed that compared to a brisk walk and refrain from jogging. After the 10 minute treatment for each participant, another score on the Visual Analog Scale was recorded as well as a third score for the sit-and-reach test and vertical jump height.

Participants reported back to the lab at approximately 24 hours post treatment for a second treatment. During this visit a pre-treatment VAS score was recorded along with

a sit-and-reach score and vertical jump height. Each participant underwent the same treatment as the day before, and then reported another post-treatment VAS score and sit-and-reach score vertical jump height.

Participants reported back to the lab for a third, fourth, and fifth treatment and data collection. Each of these treatments followed the same 24 hour timeline and protocol as previously described.

Participants were asked to continue normal activities of daily living during the five day treatment. They were, however, asked to refrain from any other treatments of DOMS, including exercise, medication, ice, stretching, therapeutic modalities, etc.

Hypotheses

Pain:

H₀: No difference exists between the treadmill walking and whole body vibration groups on post-test VAS scores.

H₁: A difference exists between the treadmill walking and whole body vibration groups on post-test VAS scores.

Range of Motion:

H₀: No difference exists between the treadmill walking and whole body vibration groups on post-test sit-and-reach scores.

H₂: A difference exists between the treadmill walking and whole body vibration groups on post-test sit-and-reach scores.

Vertical Jump:

H₀: No difference exists between the treadmill walking and whole body vibration groups on post-test vertical jump scores.

H₃: A difference exists between the treadmill walking and whole body vibration groups on post-test vertical jump scores.

Independent Variables

Whole body vibration

Treadmill walking

Dependent Variables

Perceived pain score

Hamstring and low back range of motion

Explosive power

Statistical Analysis

This study is designed as a quantitative analysis. Baseline measures were taken for perceived pain, hamstring and low back range of motion, and explosive power. These measures were repeated after induction of delayed-onset muscle soreness but prior to treatment for delayed-onset muscle soreness. The measures were also repeated after treatment for delayed-onset muscle soreness. Participants were assessed prior to and after five separate treatment sessions.

A Repeated Measures Analysis of Variance (ANOVA) was conducted on each dependent variable.

CHAPTER IV

FINDINGS

The primary purpose of this study is to identify the effect of whole body vibration (WBV) on delayed-onset muscle soreness (DOMS). The secondary purpose of this study is the effect of vibration on flexibility and power measures associated with DOMS. Data was collected at a regional university in the Southcentral United States. This chapter reports the analyzed findings for the study and discusses the results as they pertain to each hypothesis.

Seventeen participants ($N = 17$) were analyzed in this study. The WBV group consisted of six males and 3 females ($n = 9$). The controlled walking group consisted of two males and six females ($n = 8$).

Hypothesis 1:

It was hypothesized that no difference would exist between the treadmill walking and whole body vibration groups on visual analog scale (VAS) scores. An analysis of the pre-treatment and post-treatment VAS scores yielded no significant results ($p > .05$) between the control and experimental groups (Figures III and IV).

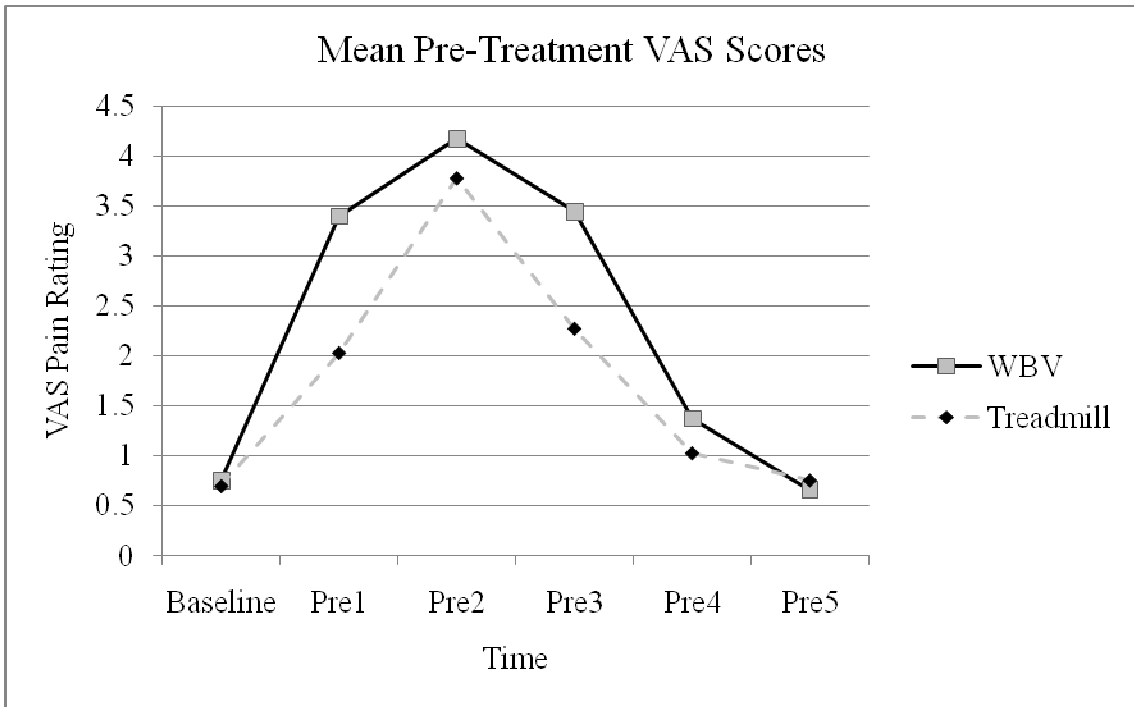


Figure III. Pre-Treatment VAS Means

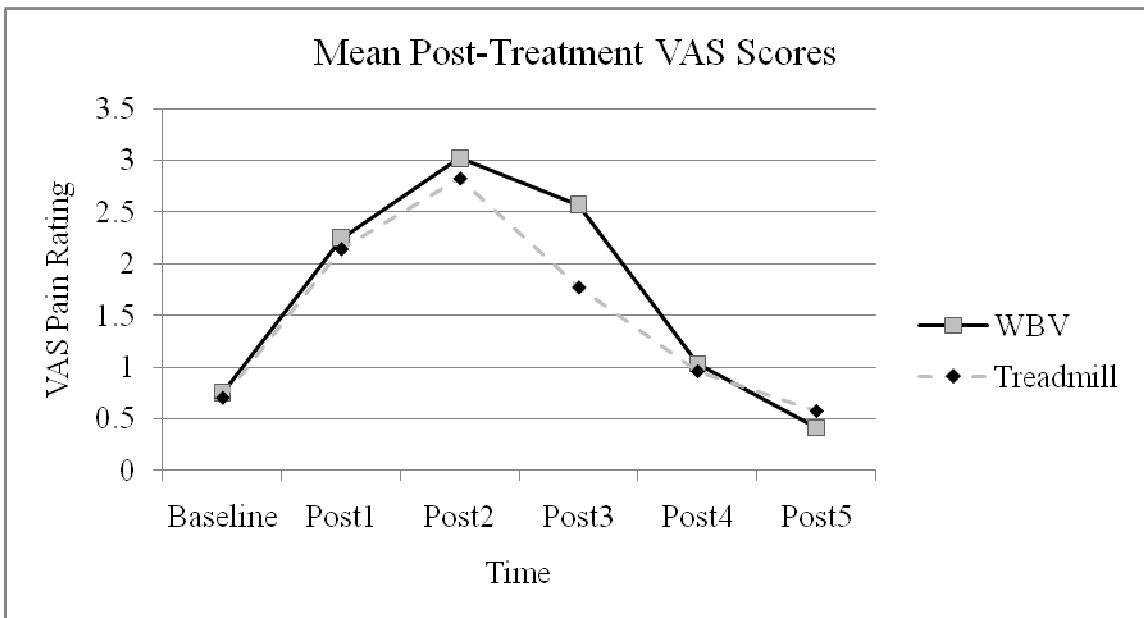


Figure IV. Post-Treatment VAS Means

Figures III and IV demonstrate comparisons between the experimental and control group VAS scores at pre-treatment and post-treatment, respectively. Both figures demonstrate a common trend with both treatments in that each treatment showed

increased VAS scores from baseline to VAS1 (day 1) and VAS2 (day 2). VAS scores peaked at VAS2 and began to taper off with VAS3-VAS5 (days 3-5).

If the average change is evaluated, some differences can be seen numerically from pre-treatment to post-treatment in mean pain rating decrease (Table 2). Participants undergoing the whole body vibration treatment decreased pain ratings by an average of 2.19 ± 2.67 , while participants undergoing the treadmill walking treatment decreased pain ratings by an average of 2.59 ± 1.76 .

	N	Minimum	Maximum	Mean	Std. Deviation
Pain Decrease Experimental	10	0.6	7.9	2.19	2.67
Pain Decrease Control	7	0.1	5.3	2.59	1.76

Table 2. Means and Standard Deviations of Pain Decrease by Group

Hypothesis 2:

It was hypothesized that no difference would exist between the treadmill walking and whole body vibration groups on sit-and-reach scores. An analysis of the pre-treatment and post-treatment sit-and-reach scores yielded no significant results ($p > .05$) between the control and experimental groups (Figures V and VI).

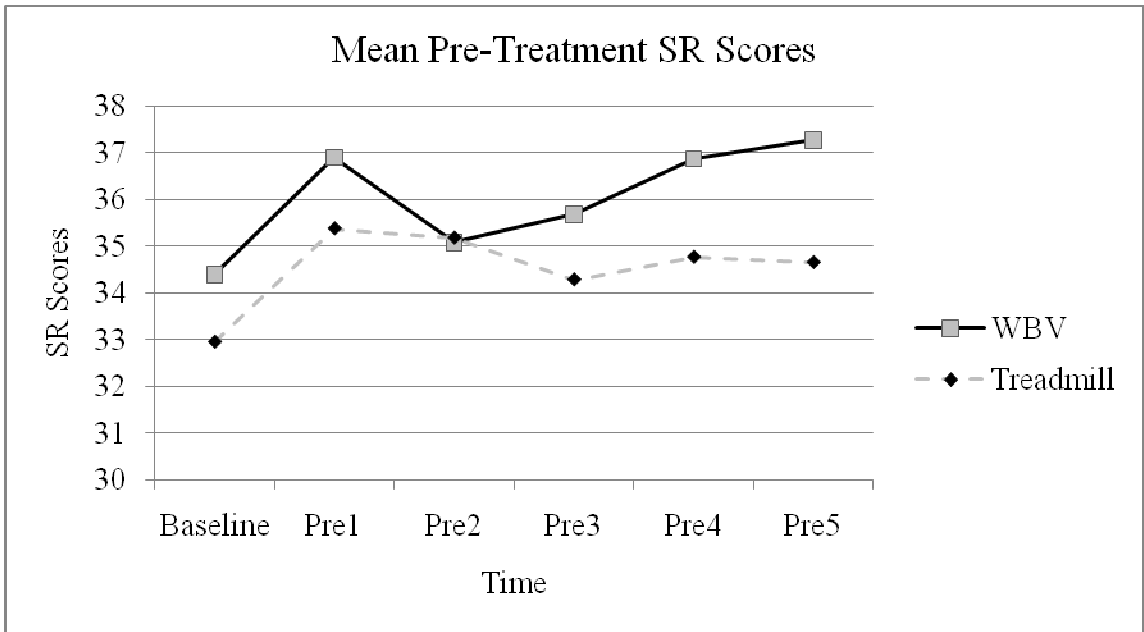


Figure V. Pre-Treatment SR Means

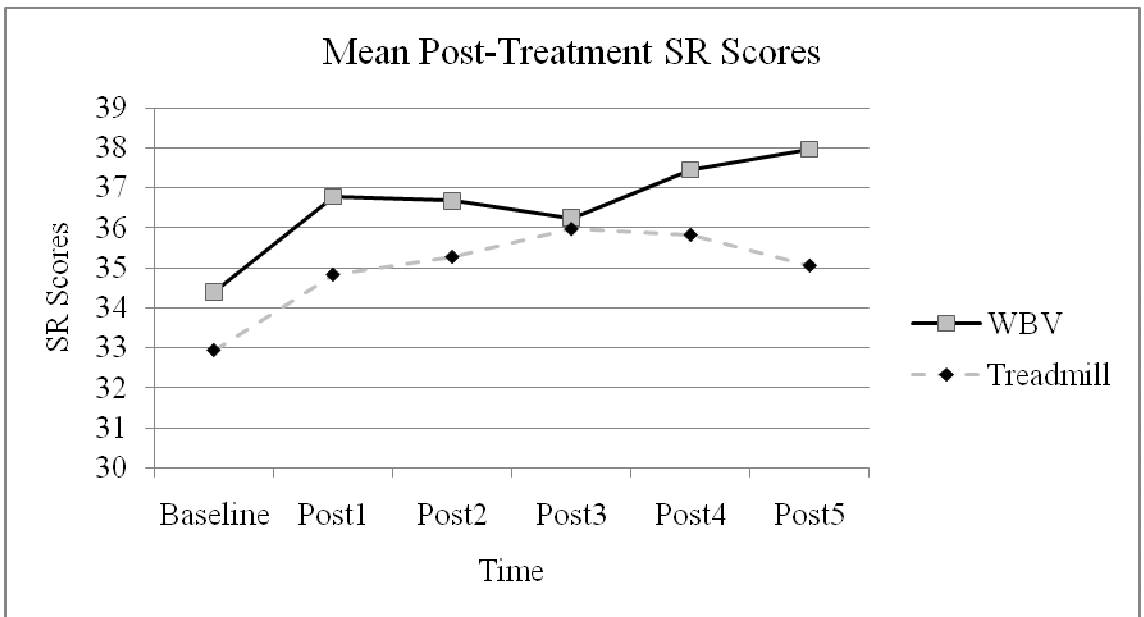


Figure VI. Post Treatment SR Means

Figures V and VI demonstrate comparisons between the experimental and control group SR scores at pre-treatment and post-treatment, respectively. Both figures demonstrate a common trend within the experimental group at both pre-treatment and post-treatment. SR scores appear to increase from baseline to SR1 (day 1) while they

decrease from at SR2 (day 2) and SR3 (day 3). SR4 (day 4) and SR5 (day 5) exhibit increases within the experimental group SR scores. The control group shows an increase in SR scores from baseline to SR1 (day 1), but a slight decrease is established from SR1 to SR2 (day 2) and SR2 to SR3 (day 3). This is followed by another increase from SR3 to SR4 (day 4) and SR4 to SR5 (day 5). The control group also shows steady increases in SR post-treatment scores from days 1-3 with decreases occurring during days 4 and 5. VAS scores peaked at VAS2 and began to taper off with VAS3-VAS5 (days 3-5).

Hypothesis 3:

It was hypothesized that no difference would exist between the treadmill walking and whole body vibration groups on vertical jump scores. An analysis of the pre-treatment and post-treatment vertical jump scores yielded no significant results ($p > .05$) between the control and experimental groups (Figures VII and VIII).

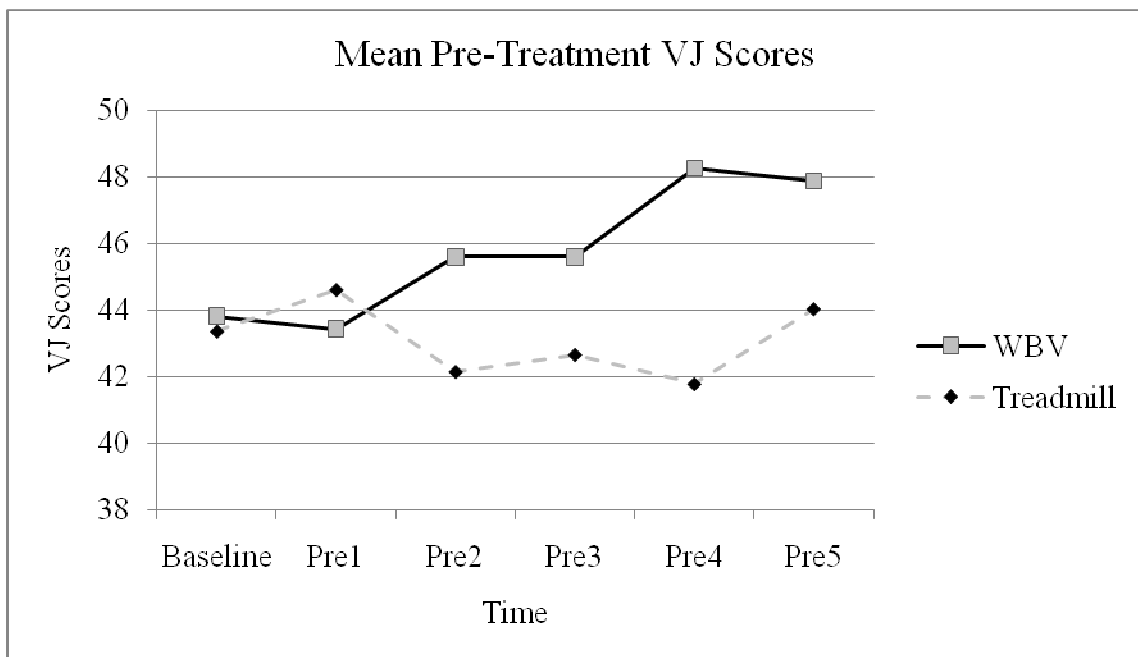


Figure VII. Pre-Treatment VJ Means

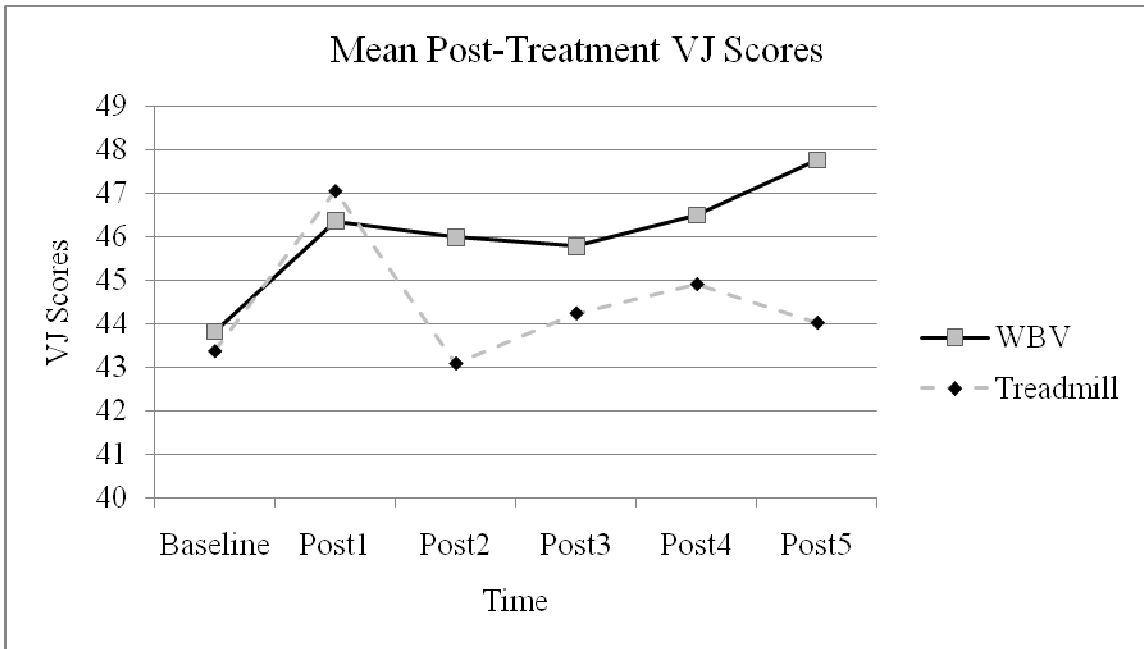


Figure VIII. Post Treatment VJ Means

Figures VII and VIII demonstrate comparisons between the experimental and control group VJ scores at pre-treatment and post-treatment, respectively. Pre-treatment VJ scores appear to decrease for the experimental group and increase for the control group at VJ1 (day 1). This opposing trend continues throughout the experimental time frame for the pre-treatment scores. Post-treatment scores increase for both the experimental and control groups from baseline to VJ1, while they decrease from VJ1 to VJ2 (day 2). From VJ2 to VJ3 (day 3), we see a decrease in post-treatment VJ for the experimental group and an increase for the control group. The experimental group then shows increases through VJ4 (day 4) and VJ5 (day 5), while the control group sees slight decrease through VJ4 and VJ5.

Numerical differences were demonstrated between vertical jump increases for the experimental and control groups (Table 3). Participants undergoing whole body vibration demonstrated a 0.25 ± 2.53 cm (0.10 ± 1.00 in) average decrease in vertical jump, while

participants undergoing treadmill walking demonstrated a 6.17 ± 9.98 cm (2.43 ± 3.93 in) average increase in vertical jump.

	N	Minimum (cm)	Maximum (cm)	Mean (cm)	Std. Deviation
Vertical Jump Increase Experimental	10	-3.81	17.78	-.25	2.53
Vertical Jump Increase Control	7	-2.54	1.27	6.17	9.98

Table 3. Means and Standard Deviations for Vertical Jump Increase by Group

Discussion

In the present study, the VAS scores show numerical decreases in pain ratings after a peak in VAS scores at day 2. Participants in the whole body vibration (experimental) group averaged a pain decrease of 2.19 ± 2.67 , while participants in the treadmill walking (control) group averaged a pain decrease of 2.59 ± 1.76 . The failure of these data to reach statistical significance may be explained by speculation that participants may not have been fully honest when assessing pain on the VAS. Literature has shown that males have demonstrated a tendency to report less pain than females (Robinson et al., 2001; Robinson & Wise, 2003; Wise, Price, Myers, Heft, Robinson, 2002). This tendency may be due in part to gender stereotypes commonly accepted by participants in research (Robinson & Wise, 2003) as experimental pain and clinical pain ratings have shown discrepancy as gender roles are established in a laboratory setting (Robinson et al., 2001). The use of lunges as the exercise to induce DOMS may have played a role in the lack of robust change seen in the VAS scores. While lunges are popular exercises in producing DOMS of the hamstrings and gluteals, a more standard approach to establishing DOMS in these muscles is the use of an isokinetic dynamometer

such as the Biodex[®] or Cybex[®]. Participants were also asked to refrain from other forms of pain relief (i.e. NSAIDS, ice application, ultrasound treatments, exercise, etc.). The investigator made the request in good faith; however, no control was had over the participants' activities outside of the laboratory setting.

Although these results failed to reach statistical significance ($p = 0.833$), the decreases shown are important to recognize as any change in pain rating may influence activities of daily living, athletic participation, and athletic performance (Ebbeling & Clarkson, 1989; Rowlands et al., 2001; Saxton et al., 1995). Literature has shown bouts of eccentric exercise to induce DOMS and create impairments in neuromuscular function. Specifically, Saxton et al. (1995) found a prolonged increase in physiological tremor and a loss of force proprioception after a bout of eccentric exercise. Rowlands et al. (2001) found a decrease in strength associated with DOMS produced in downhill running with different stride lengths; although this strength deficit was not found to be significant, the decrease may have an influence on performance. Taken together, these individual performance decreases could impair the ability to perform certain motor tasks associated with activities of daily living, athletic participation, or athletic performance.

With this idea of recognizing even the small changes in pain ratings and performance comes the question, "What is a meaningful change?" The idea of clinical trials in therapeutic treatments is essentially to identify a defined point of pain decrease for a patient. This point may be indicated by the patient reporting no additional treatment necessary for the required activity tested (Farrar, Portenoy, Berlin, Kinman, & Strom, 2000). Farrar, Young, LaMoreaux, Werth, & Poole (2001) recommend reporting the clinical relevance of pain decrease in terms of percent change. While, pain reduction rates

of 30% have been identified as clinically important, pain decreases of 27.9% are indicated to show much or very much improvement (Farrar, Young, LaMoreaux, Werth, & Poole, 2001). When this pain reduction rate is taken into account, the data from the present study indicate VAS scores on Day 2 for WBV approach clinical importance with a mean percent reduction of 28.69%, while VAS scores on Day 3 for treadmill walking approach clinical importance with a mean percent reduction of 29.62%.

Participants in the experimental group exhibited a 0.61 ± 3.95 cm (0.24 ± 1.56 in) average decrease in flexibility in comparison to a 2.10 ± 3.50 cm (0.83 ± 1.38 in) average increase exhibited in the control group. Again, no statistical significance ($p = 0.829$) was reached by the reported data. While literature demonstrates physical activity may alleviate flexibility issues associated with DOMS (Cheung et al., 2003; Rahnama, Rahmani-Nia, & Ebrahim, 2005; Wessel & Wan, 1994), no literature can be found to demonstrate that whole body vibration has the same effects. The idea of increased local blood flow to the area by whole body vibration is often looked at as a factor that would be expected to decrease the perception of DOMS (Rhea et al., 2009); however, the argument could be made that an increase in blood flow to the area has indeed caused inflammation, which in turn shows decreases in range of motion (Smith, 1991; Howell, Chila, Ford, David, & Douglas, 1985). Muscle soreness has also shown to inhibit flexibility measures (Cheung et al., 2003; Rowlands et al., 2001; Smith, 1992). We can infer that the limited changes in flexibility may also be due in part to the insignificant decrease in VAS scores reported in this study.

It is interesting to note that vertical jump scores for the experimental group decreased by an average of 0.25 ± 2.53 cm (0.10 ± 1.00 in), while vertical jump scores

for the control group increased by an average of 6.17 ± 9.98 cm (2.43 ± 3.93 in). These changes are observed as averages of delta scores from baseline measures to post-treatment measures on Day 5. While these data also failed to reach statistical significance ($p = 0.054$), it is important to note previous findings of significance in relation to whole body vibration and vertical jump scores. Current literature demonstrating a significant treatment interaction on vertical jump scores utilizes somewhat decreased exposure to whole body vibration (Lamont et al., 2010) in comparison to the method employed in the present study. The insignificance seen in the present study may be due in part to prolonged exposure to whole body vibration. As documented in Armstrong et al. (2008), the Hoffmann reflex (H-reflex), a measure of motoneuron excitability, was suppressed during the first minute after a bout of WBV with suppression lasting between three and thirty minutes thus suggesting fatigue as a result of WBV. No measures of the H-reflex were taken during the present study; however, it is important to address the H-reflex as a possible explanation to the insignificant findings due to its documentation in the literature.

While the present study showed no significant findings, the small differences seen would lead us to further investigate these variations. A possible modification to this study would be to induce DOMS with a more standard method (i.e. Biodex[®] or Cybex[®]). These methods have shown to be reliable in producing DOMS and are currently widely used in research. The use of chemical markers to identify the extent of DOMS may also be employed to better identify whether or not DOMS has been truly induced. Using a pressure algometer to identify pain levels may yield more accurate findings in pain scores. Range of motion measures may be better served in using a goniometer rather than

the sit-and-reach method. While the sit-and-reach method is widely employed in research for its ease of use and timeliness, questions still exist regarding the true amount of motion measured. Further, gender differences do exist in pain scores, flexibility, and explosive power. A better option for drawing conclusions to these dependant variables in relation to whole body vibration may be to only assess one gender at a time and to include more participants overall as this will increase power.

CHAPTER V

CONCLUSION

Summary

This study measured the changes in perceived pain through Visual Analog Scale (VAS) scores, flexibility through sit-and-reach (SR) test scores, and explosive power through vertical jump (VJ) scores. Ten females (20.2 ± 1.48 years) and 10 males (21.5 ± 1.96 years) from a regional university in the Southcentral United States volunteered for participation in the study. Participants were excluded from the study if:

- 1) they reported any injury to the upper or lower extremity, the back, or the abdominals within the past 6 months that held them from normal activities of daily living;
- 2) they reported any surgical procedure within the past 12 months that held them from normal activities of daily living for more than one (1) month; or
- 3) they reported any neurological issues.

Upon completion of data collection, three participants were deemed as outliers and were excluded from data analysis.

All participants were asked to sign an informed consent and complete a health history questionnaire approved by the Institutional Review Boards at both Oklahoma State University and Arkansas State University. The health history questionnaire

provided information to determine suitability for participation in the study. Once participants were deemed eligible for involvement in the study, measures were taken for height and weight along with baseline measures for pain (VAS), flexibility (SR), and explosive power (VJ). Participants were then randomly placed in either the experimental (whole-body vibration [WBV]) or control (treadmill walking [TW]) treatment groups.

In order to induce delayed-onset muscle soreness (DOMS), each participant was asked to perform three sets of 10 lunges while holding dumbbells equal to 12-18% of their body weight. This exercise was performed under the supervision of a certified athletic trainer with experience in proper instruction of strength exercises. Participants were then asked to repeat the same measures (VAS, SR & VJ) taken earlier before undergoing the treatment protocol. Participants experienced a 10-minute treatment through either WBV or TW. Post-treatment measures were then taken after the treatment session on the VAS, SR & VJ. Participants reported to five consecutive testing sessions with session one being the induction of DOMS as noted above and the initial treatment. Sessions two through five did not include lunging exercises and were focused on pre-treatment measures, the treatment, and post-treatment measures.

Findings

Hypothesis 1 stated no difference would exist between the TW and WBV groups on post-test VAS scores. It was determined that no statistical significance existed between groups ($p = 0.883$) and that WBV had no effect on perceived muscle soreness in subjects with DOMS.

Hypothesis 2 stated no difference would exist between the TW and WBV groups on post-test SR scores. No statistical significance existed between groups ($p = 0.829$) indicating that WBV does not increase flexibility in subjects with DOMS.

Hypothesis 3 stated no difference would exist between the TW and WBV groups on post-test VJ scores. No statistical significance existed between groups ($p = 0.054$) indicating that WBV does not increase vertical jump in subjects with DOMS.

Limitations

Limitations of this study include a small participant pool, male and female participants, and only small amounts of induced soreness. The small number of participants in the study creates a power deficit in the overall study. It would be wise to increase the participant pool in a future project. While many studies include both male and female participants, studies involving pain assessment and performance indicators may be better served by separating the two genders. Literature shows differences between males and females in all assessments involved in the present study. While a rationale for the small amounts of induced muscle soreness can only be speculated, a more standard method of eccentric exercise may be necessary in future studies of this nature.

Conclusions

While results showed no statistical significance, differences were noted between groups. These differences indicate that changes were taking place but not to the statistically significant level. Pain ratings on the VAS did decrease, and one might argue that those pain ratings decreased enough to be considered clinically important. As researchers, we look to find the statistical significance of treatments, when in actuality the important component of successful research is the clinical significance.

SR scores showed an interesting trend with the experimental group actually losing flexibility while the control group gained flexibility. The inflammatory theory of DOMS would lend itself to the explanation of this trend taking into account that the WBV group did no exercise to remove any inflammation that may be trapped within the muscle, while the concentric activity associated with the TW group assisted in the removal of the inflammation.

VJ scores nearly reached statistical significance ($p = 0.054$). This failure to reach statistical significance may be explained partly by the concept of the Hoffmann reflex (H-reflex) suffering suppression post-treatment. Literature demonstrates a suppression time of the H-reflex at 3-30 minutes after WBV exposure. Should the VJ measures be taken after a 30 minute wait, it is possible these results would demonstrate statistical significance.

Recommendations

Further investigation is needed regarding the use of WBV as a treatment option for DOMS. This study revealed trends lending themselves to support WBV as a treatment for DOMS, however, no statistical significance was reached. These trends lead us to identify areas for future research and modifications to the current study that may eliminate more error and define statistical significance.

While the VAS is often used in studies involving pain levels, the VAS alone may not express a true indication of the severity of pain. Combining the VAS with a pressure algometer or using the pressure algometer alone may show more accurate pain ratings. The current study simply employed the VAS in relation to the question, “How sore do you feel today?” This method does not designate specific areas of pain perception

whereas a pressure algometer can pinpoint areas of increased pain. Should the investigator forego the use of a pressure algometer, a more appropriate description may be necessary to indicate exactly what the investigator is trying to assess with the VAS.

Use of the Biodex[®] or Cybex[®] to induce DOMS may improve the likelihood that a case of DOMS will be substantial enough for treatment exploration. The method employed in this study may not have created an extensive case of DOMS. Another rationale for the insignificant findings in reported pain associated with DOMS may have been the honesty of participants abstaining from other pain relieving mechanisms. A post-treatment questionnaire may help to identify any alterations the participants may have made to their experienced pain.

Changes to the methods of measuring flexibility include the use of a goniometer rather than the SR method. Literature demonstrates continued use of the SR method while questions still exist regarding the amount of motion measured accurately. Certainly, the SR method is convenient and quickly administered; however, goniometry may be of more benefit as it allows the researcher to assess specified motion. It would certainly be important for intra-tester reliability to be established if this method was employed.

A longer wait period between treatment on the WBV unit and the re-test of the VJ may be beneficial. The H-reflex has shown a decrease in function to range from 3-30 minutes post-treatment with WBV. An analysis of this measure after the H-reflex has increased functionality may show a significant change.

A more specific target population may also exhibit statistical significance. Literature explores differences between genders regarding pain scores, flexibility, and explosive power. While these gender differences are important to note in relation to

performance enhancement and injury prevention, this study was aimed to find an overall treatment effect. A better option for exploring that treatment effect may be to concentrate on one gender at a time rather than compare both genders within groups. Increasing the number of participants would also be an avenue of exploration as this will increase the power and in turn give more credibility to the research.

Clinical Implications

It is apparent that whole body vibration is gaining momentum in the world of sports. The idea of this study was to identify a method of treating DOMS to decrease pain and improve flexibility and vertical jump. While this study failed to reach statistical significance with regards to a treatment protocol for delayed-onset muscle soreness, clinical importance was established on Day 2 for the experimental group in relation to pain, while clinical importance was established on Day 3 for the control group in relation to pain. Clinicians should take a closer look at the implications of whole body vibration for both the athletic and general population clientele.

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APPENDICES

Appendix A – Informed Consent

Project Title: The Effect of Whole Body Vibration on Delayed Onset Muscle Soreness

Investigators:

Amanda A. Wheeler, MS, LAT, ATC, CSCS
Oklahoma State University & Arkansas State University
Bert H. Jacobson, PhD
Oklahoma State University

Purpose:

The purpose of this study is to determine the effects of whole body vibration on delayed onset muscle soreness.

Procedures:

You will report to 5 data collection sessions over the span of 5 days. You will report to the Human Performance Laboratory of Arkansas State University (HPSS 102). Upon arrival to the first data collection, you will be asked to read and sign a consent form (see attached). If you choose to participate, you will then be asked to complete a health history questionnaire in order to determine eligibility for the research.

A certified athletic trainer will be present at testing. The certified athletic trainer will review the health history questionnaire and determine eligibility for participation. You will be excluded if:

- 1) you report any injury within the past 6 months that has held you from normal activities of daily living.
- 2) you report any surgical procedure within the past 12 months that has held you from normal activities of daily living for more than one (1) month.

Successfully passing the health history questionnaire will result in you having height and weight measured followed by an assessment of your baseline sit-and-reach test (a test in which you will sit on the floor an lean forward as though you are touching your toes) score and vertical jump (a jump straight up from the floor) height. You will then be randomly assigned into the treatment or control group. You will then be asked to perform three sets of 10 lunges (an exercise in which you will step forward with one leg or the other and do a partial squat) while holding dumbbells. The weight of the dumbbells will be determined based on your weight measures. Approximately 12% to 18% of total body weight will be used to identify the weight of each dumbbell. This exercise is designed to induce delayed onset muscle soreness in the legs and buttocks. You are expected to experience mild to moderate soreness in the legs and buttocks region. You will immediately report Visual Analog Scale (VAS) pain measures (place a line on a 10 cm line to indicate your pain rating) and will again be assessed for sit-and-reach scores and vertical jump height. Should you be assigned to the treatment group, you will then spend 10 minutes on the VibraTrim VT100[®] (VibraTrim, LLC, Gig Harbor, WA). Speed will be adjusted on the VibraTrim VT100[®] as the timer counts down from 10. (See attached chart for detail). Should you be assigned to the treatment group, you will then spend 10 minutes walking at a comfortable pace on the Woodway Desmo (Woodway USA, Waukesah, WI) treadmill. After the 10 minute treatment, another score on the Visual Analog Scale will be recorded as well as a third score for the sit-and-reach test and vertical jump height.

You will report back to the lab at approximately 24 hours post treatment for a second treatment. During this visit a pre-treatment VAS score will be recorded along with a sit-and-reach score and vertical jump height. You will participate in the same treatment as the day before, and will then report another post-treatment VAS score and sit-and-reach score and vertical jump height.

You will report back to the lab at approximately 24 hours post treatment for a third treatment. During this visit a pre-treatment VAS score will be recorded along with a sit-and-reach score and vertical jump

height. You will participate in the same treatment as the day before, and will then report another post-treatment VAS score and sit-and-reach score and vertical jump height.

You will report back to the lab at approximately 24 hours post treatment for a third treatment. During this visit a pre-treatment VAS score will be recorded along with a sit-and-reach score and vertical jump height. You will participate in the same treatment as the day before, and will then report another post-treatment VAS score and sit-and-reach score and vertical jump height.

You will report back to the lab at approximately 24 hours post treatment for a third treatment. During this visit a pre-treatment VAS score will be recorded along with a sit-and-reach score and vertical jump height. You will participate in the same treatment as the day before, and will then report another post-treatment VAS score and sit-and-reach score and vertical jump height.

A maximum of two participants may be tested at one time.

Risks of Participation:

You will perform weighted lunges in order to induce delayed onset muscle soreness. This exercise will make the legs and buttocks sore. You should experience mild to moderate soreness. The whole body vibration system and walking will serve as the attempt to decrease the amount of muscle soreness experienced by each participant.

Benefits:

Muscle soreness resulting approximately 24-48 hours after exercise is commonly defined as delayed onset muscle soreness. Delayed onset muscles soreness (DOMS) is an essential part of beginning a new workout program. Identifying potential ways to decrease or eliminate the effects of DOMS, may lead to faster recovery times and potentially fewer sustained injuries due to improper muscle activation and use.

Confidentiality:

All information about you will be kept confidential and will not be released. Questionnaires and record forms will have identification numbers, rather than names, on them. Research records including the health history questionnaires will be stored securely in the principal investigator's office at Arkansas State University (HPESS 222), and only researchers and individuals responsible for research oversight will have access to records. This information will be saved as long as it is scientifically useful; typically, such information is kept for 5 years after publication of the results. Results from this study may be presented at professional meetings or in publications. You will not be identified individually; we will be looking at the group as a whole. It is possible that the consent process and data collection will be observed by research oversight staff responsible for safeguarding the rights and wellbeing of people who participate in research.

Compensation:

No compensation will be given to participants for participation in this study.

Contacts:

Amanda A. Wheeler
HPESS 222
Arkansas State University
Jonesboro, AR 72467
870-972-3066

Dr. Bert Jacobson
204 Willard Hall
Oklahoma State University
Stillwater, OK 74078
405-744-6632

If you have questions about your rights as a research volunteer, you may contact Dr. Shelia

Kennison, IRB Chair, 219 Cordell North, Stillwater, OK 74078, 405-744-3377 or irb@okstate.edu.

You may also contact Dr. David Holman, Center for Excellence in Education Chairman Institutional Review Board, Arkansas State University at 870-972-3943 or dholman@astate.edu.

Participant Rights:

Your participation in this research is voluntary. There is no penalty for refusal to participate, and you are free to withdraw your consent and participation in this project at any time, without penalty. Participation in this research is voluntary. In case of injury or illness resulting from this study, emergency medical treatment will be available. No funds have been set aside by Oklahoma State University or Arkansas State University to compensate you in the event of illness or injury.

Consent Documentation:

By signing below you indicate the following:

- 1) You have been fully informed about the procedures listed here. You are aware of what you will be asked to do and the benefits of your participation. You also understand the following statements:
 - a. You affirm that you are 18 years of age or older.
 - b. You have read and fully understand this consent form. You sign it freely and voluntarily.
 - c. A copy of this form will be given to you.
- 2) You understand the data collected will be stored securely in the office of the principal investigator.
- 3) You hereby give permission for your participation in the study.

Signature of Participant

Date

I certify that I have personally explained this document before requesting that the participant sign it.

Signature of Researcher

Date

Appendix B – Health History Questionnaire

Participant ID Number & Health History Questionnaire

Please answer the following questions to the best of your knowledge. Please place a check in the appropriate box. All information from this questionnaire will be kept confidential.

Participant ID number: _____

Please indicate the most appropriate answer to the following questions	Yes	No
1. Have you experienced an injury to the lower extremity within the past 6 months?		
2. Have you experienced an injury to the upper extremity within the past 6 months?		
3. Have you experienced an injury to the abdominals within the past 6 months?		
4. Have you experienced an injury to the back within the past 6 months?		
5. Have you had any surgical procedures performed on the lower extremity within the past year?		
6. Have you had any surgical procedures performed on the upper extremity within the past year?		
7. Have you had any surgical procedures performed on the abdominals within the past year?		
8. Have you had any surgical procedures performed on the back within the past year?		
9. Do you have a history of neurological problems?		
10. Are you currently taking any medication? If yes, please list:		

Please explain any “YES” responses below.

*If you become ill and/or unable to finish the study, alert the investigator (s) immediately.

Appendix C – Visual Analog Scale

Subject # _____

Day 1

Baseline VAS

0 10
No Pain Most Extreme Pain

Post-Exercise VAS

0 10
No Pain Most Extreme Pain

Post-Treatment VAS

0 10
No Pain Most Extreme Pain

Day 2

Baseline VAS

0 10
No Pain Most Extreme Pain

Post-Treatment VAS

0 10
No Pain Most Extreme Pain

Day 3

Baseline VAS

0 10
No Pain Most Extreme Pain

Post-Treatment VAS

0 10
No Pain Most Extreme Pain

Day 4

Baseline VAS

0 10
No Pain Most Extreme Pain

Post-Treatment VAS

0 10
No Pain Most Extreme Pain

Day 5
Baseline VAS

0 10
No Pain Most Extreme Pain

Post-Treatment VAS

0 10
No Pain Most Extreme Pain

Appendix D – Experimental Treatment Protocol

Speed Adjustment

Speed	Duration	Timer Reading at Change
8	1 Minute	9:00
11	2 Minutes	7:00
14	2 Minutes	5:00
18	4 Minutes	1:00
14	1 Minute	0:00

Appendix E – IRB Approval

Oklahoma State University Institutional Review Board

Date: Wednesday, January 19, 2011
IRB Application No ED10160
Proposal Title: The Effect of Whole Body Vibration on Delayed Onset Muscle Soreness

Reviewed and Processed as: Expedited

Status Recommended by Reviewer(s): Approved Protocol Expires: 1/18/2012

Principal Investigator(s):

Amanda A. Wheeler	Bert Jacobson
PO Box 240	204 Willard
State University, AR 72467	Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Beth McTernan in 219 Cordell North (phone: 405-744-5700, beth.mcternan@okstate.edu).

Sincerely,



Shelia Kennison, Chair
Institutional Review Board

VITA

Amanda A. Wheeler

Candidate for the Degree of

Doctor of Philosophy

Dissertation: THE EFFECT OF WHOLE BODY VIBRATION ON DELAYED-
ONSET MUSCLE SORENESS

Major Field: Health, Leisure, and Human Performance

Biographical:

Education:

Completed the requirements for the Doctor of Philosophy in Health, Leisure,
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MS, Health & Physical Education
Marshall University, Huntington, WV, 2006

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Experience:

Instructor – Department of Health, Physical Education, & Sport Science
Arkansas State University, 2010

Instructor – School of Human Performance & Recreation
The University of Southern Mississippi, 2009-2010

Graduate Assistant – Department of Health, Leisure, & Human Performance
Oklahoma State University, 2006-2009

Professional Memberships:

NATA, SWATA, AATA, SEATA, MATA, NSCA

Name: Amanda A. Wheeler

Date of Degree: May, 2011

Institution: Oklahoma State University

Location: Stillwater, Oklahoma

Title of Study: THE EFFECT OF WHOLE BODY VIBRATION ON DELAYED-
ONSET MUSCLE SORENESS

Pages in Study: 82

Candidate for the Degree of Doctor of Philosophy

Major Field: Health, Leisure, and Human Performance

Scope and Method of Study: The purpose of this study was to examine the effects of whole body vibration (WBV) on delayed-onset muscle soreness, specifically pain ratings, sit-and-reach scores, and vertical jump scores. Participants in the study were 20 (10 male; 10 female) healthy, college-aged students (20.85 ± 1.81 years). All students completed an IRB informed consent document and health history questionnaire to determine eligibility. Participants were randomly assigned to a treatment or control group. For each participant, delayed-onset muscle soreness was induced via weighted lunges. Subsequently, the experimental treatment group underwent 10min. WBV before and after assessment for five consecutive days while the control group walked on a treadmill before and after each assessment. Assessment included visual analog pain rating, flexibility, and vertical jump measures.

Findings and Conclusions: No significant results were found between the control and experimental groups regarding pain ratings, sit-and-reach scores, and vertical jump scores. While not statistically significant, differences were noted between groups. Pain ratings showed overall decreases after the expected increase during the 48 hours following the induction of DOMS. Sit-and-reach scores showed trends of increasing flexibility in the control group. And vertical jump scores approached statistical significance. Several factors may have played a part in the lack of statistical significance of these data. However, this area should be explored further with modifications to this study.

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