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ACUTE EFFECTS OF WHOLE BODY VIBRATION EXERCISES WITH VARIOUS FREQUENCIES AND AMPLITUDES ON ARTERIAL STIFFNESS IN MALES

BY

OMAR APODACA

A THESIS PRESENTED TO THE GRADUATE FACULTY OF THE COLLEGE OF EDUCATION IN PARTIAL FULLFILLMENT OF THE REQUREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN EXERCISE SCIENCE

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JULY 2014

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CHAPTER I

INTRODUCTION

In the last two decades, cardiovascular diseases have exponentially increased among the general populations of the world reaching alarming numbers in most of the countries no matter if they are considered developed or underdeveloped nations. Cardiovascular diseases are the number one cause of morbidity and mortality among humans accounting for approximately 17 million deaths or 30% of the total deaths worldwide (World Health Organization [WHO], 2012). According to the World Health Organization (WHO), this cardiovascular disease issue will continue to increase and will be considered to be the cause of more than 30 million deaths annually by 2030.

According to the American Heart Association most of the cardiovascular diseases are caused in part due to arteriosclerosis or the hardening of the blood vessels that is a process caused by the accumulation of plaque on the arterial walls and due to age. Arterial stiffening has been identified as the earliest sign of arterial damage, becoming important predictor for cardiovascular diseases and cardiac events. Arterial stiffness can be measured via Pulse Wave Velocity (PWV) which is a simple, non-invasive method considered the gold standard due to its reliability and ability to predict cardiovascular diseases (Oliver & Webb, 2003; Vlachopoulos, Aznaouridis, & Stefanadis, 2010).

Physical activity is a key aspect for the maintenance of cardiovascular health and fitness. The American College of Sports Medicine (ACSM) recommends 150 minutes of moderate-vigorous physical activity a week, that is, 30-60 minutes of moderate activity 5 days/week. Physical activity, especially aerobic physical activity has been proven to be effective in reducing arterial stiffness and the risk for cardiovascular diseases.

Whole body vibration is a recent training modality in which a vibration platform is used to produce vibrations that travel through the body. This type of training has been tested in sports settings, clinical and rehabilitation settings as well as aeronautical science. Research in whole body vibration training has shown to be effective in increasing bone density, increasing muscle strength, improved blood flow and reduce arterial stiffness (Chanou, Gerodimos, Karatrantou, & Jamurtas, 2012).

Study Purpose

The purposes of the study were: 1) To examine the acute effects of dynamic whole body vibration (WBV) training on small and large arterial stiffness; 2) To examine the effects of different frequency and amplitude protocols in heart rate (HR), systolic and diastolic blood pressure, mean arterial pressure (MAP), cardiac output (CO), and stroke volume (SV); 3) Identify the best WBV protocol to decrease acutely arterial stiffness.

Research Questions

1. Are there any changes in small and large arterial stiffness following a bout of whole body vibration workout with the different amplitude and frequency?
2. Are there any changes in heart rate (RHR), systolic and diastolic blood pressure, mean arterial pressure (MAP), cardiac output (CO) and stroke volume (SV) following a bout of whole body vibration workout with the different amplitude and frequency?
3. Which vibration settings would show the best results in decreasing arterial stiffness?

Hypotheses

1. There would be different changes in small and large arterial stiffness when using different amplitudes and frequencies.
2. Amplitude and frequency would create different changes in HR, SBP, DBP, MAP, CO and SV after a bout of WBV.
3. Lower frequency in combination with high amplitude would be the best protocol to decrease arterial stiffness.

Significance of the Study

It is well documented the high incidence of cardiovascular diseases around the world and the high risk of death due to them (American Heart Association, 2010; Vella, 2011; World Health Organization, 2012). It is also proven that physical activity is one of the main factors in cardiovascular health and the positive influence that physical activity has on reducing risk factors such as obesity and arterial stiffness. Research on new methods of training, which includes Whole Body Vibration (WBV), is of high importance to provide new and different options and opportunities for individuals to improve their health status.

Whole body vibration is an effective technique in improving various health markers such as muscle strength, blood circulation, bone density, balance improvement and cardiovascular health in clinical patients. The latest research has shown that WBV is effective in reducing arterial stiffness both acutely and permanently in different populations. Even with these promising findings, the mechanisms involved in these results are not totally understood neither specific protocol to reduce arterial stiffness using WBV training have been investigated and established, therefore, it is essential to study the effects of different vibration protocols including

the combination of different frequencies and amplitudes in order to identify the most effective protocol to decrease arterial stiffness.

Delimitations

1. Only adult males aged 18 – 40 were included in the study.
2. The exclusion of individuals with known cardiovascular disease.
3. The exclusion of all individuals with a history of participation in a regular training program within the last six months prior to study.
4. The exclusion of individuals with disabilities or diseases preventing them from completing the study.

Limitations

1. Subject sample consisted of volunteers; therefore the sample might not be representative of the population.
2. Personal and medical information was self-reported.
3. Participants were asked to present to the study fasted for at least 8 hours before testing and to abstain from intense exercise 24 hours prior to the testing but was not possible to control.

Assumptions

1. All subjects would complete the study.
2. Accurate information about the medical and health history was provided by each participant.
3. The equipment was reliable and provided accurate information for all testing sessions.
4. Each participant followed the instructions given by researcher.

Operational Definitions

PAR-Q (Physical activity readiness questionnaire)**.-** is designed to identify the small number of adults for whom physical activity might be inappropriate or those who should have medical advice concerning the type of activity most suitable for them.

Physical Activity (PA).- Any bodily movement produced by the contraction of skeletal muscles that result in substantial amount increased energy expenditure over resting energy expenditure.

Sedentary/recreationally active. - Lack of moderate physical activity for at least 30 minutes or more on most days of the week or no participation of physical activity.

Whole body vibration (WBV) Training method consisting in a platform which creates vibration stimuli that travels through the body.

Pulse Wave Analysis (PWA).- Noninvasive method to asses arterial damage, health and elasticity.

Pulse Wave velocity (PWV).- Measurement of the speed in which the stimulus travels through the arteries. Indicator of arterial damage.

CHAPTER II

REVIEW OF THE LITERATURE

Cardiovascular disease

According to the World Health Organization (WHO) cardiovascular disease (CVD) is the leading cause of morbidity and mortality around the world accounting in 2008 for an estimated 17 million deaths or 30% of the total deaths worldwide (2012). Cardiovascular diseases are also the leading cause of morbidity and mortality in developed countries; more specifically the case of the United States where caused for 831, 272 deaths which correspond to 34.3% of the total deaths in 2006. It is estimated that among the United States population 81,100,000 American adults have 1 or more cardiovascular diseases (Thomas & Williams, 2008; American Heart Association, 2010).

The presence of risk factors such as diabetes, obesity, high blood pressure, and sedentary lifestyle are strongly related to cardiovascular diseases and the incidence of cardiac events. These risk factors incidence is growing globally and even at a higher rate among the United states population. One particular concern relates to insufficient amounts of physical activity (PA) that leads to gains in excess body fat along with other health related consequences associated with carrying too much adipose weight (Wilson, Mack, & Grattan, 2008). Physical activity not only helps to maintain a healthy body mass index (BMI) but also help in the prevention and management of metabolic and heart diseases (Vella, 2011; World Health Organization, 2012).

Arterial stiffness

Arteries are a complex network of elastic conduits that distribute the continuous flow of nutrients into the tissues due to the pulsatile output of the heart. Arteries as well as any tissue have specific physical, structural and physiological properties in order to function properly. When some of the properties within the blood vessels are lost the system has to adapt and work harder which in some cases cause problems and illness. One of the earliest signs of these changes in the structures of the arteries is the stiffness of the arteries (Cavalgante, Lima, Redheuil, & Al-Mallah, 2011). Arteriosclerosis is the degenerative stiffness of the arteries or loss in elasticity is a normal process seen normally with aging but it could also be increased and accelerated by different risk factors such as hypertension (Castello, Boutouyrie, Laurent, & Volpe, 2007). The increased stiffness of the arteries especially in large arteries is due to changes in the various layers of the arterial wall, reductions and disarranging in of the elastic lamellae, substitution of elastin fibers for collagen, thickening of arterial media as well as fibrosis and calcification (Zoungas & Asmar, 2007).

Over the years arterial stiffness has increasingly been recognized as a well-established risk factor for CVD and arterial stiffening is now even considered the surrogate end point for heart disease (Vlachopoulos, Aznaouridis, & Stefanadis, 2010). Arterial elasticity has a big impact in minimizing cardiac work and to provide adequate coronary perfusion (Kinwell et al., 1997). Arterial elasticity in central arteries act as an aid to control arterial pressure and the loss of this compliance in the function of coronary arteries is strongly associated with future CVD. Small artery elasticity also has an important role, absorbing pulsatile energy during the systolic component of the cardiac cycle creating a smoother blood flow (Hayashi et al., 2005).

There are two mechanisms in which arterial stiffness will create a burden on cardiac stress and ultimately bring cardiac dysfunction. The first by making the wave travel faster and therefore, travel back to the heart during the systolic phase creating an increase in left ventricular overwork, which will create with time, left ventricular hypertrophy and then left ventricular dysfunction that could lead to cardiac failure. The second way is by creating a decrease in aortic pressure during the diastolic phase which will complicate coronary diffusion creating myocardial ischemia (Mattace-Raso, et al., 2006; Adji, O'Rourke, & Namasivayam, 2011).

Arterial stiffness can also have important negative effects in organs with high perfusion such as brain and liver, this is due to the loss in ability of the arteries to absorb some of the pressure created by the heart with every pulsation. This pressures and pulsations get into the organs and microvasculature increasing the risk for wall rupture, micro-hemorrhages and thrombotic obstruction resulting in micro infarcts of the liver, brain and ultimately stroke and dementia predisposition (Adji, O'Rourke, & Namasivayam, 2011; Zoungas & Asmar, 2007). Arterial stiffness has been proposed as an important predictor of cardiovascular disease therefore also proposed to be included as a tool to be integrated into the battery of tests to more efficiently identify risk factors and implement interventions to decrease the morbidity and mortality that having increased arterial stiffness from cardiovascular diseases (Castello, Boutouyrie, Laurent, & Volpe, 2007).

Arterial stiffness and age

Age is a determining factor on arterial stiffness in humans. As many studies have shown, there is a direct relationship between the age of a subject and the increment on arterial stiffness (Adji, O'Rourke, & Namasivayam, 2011; Viatkevicius, et al., 1993; MCEniery, Wilkinson, & Avolio, 2007). Arterial aging has been seen in healthy populations due to the normal changes in

structure of the blood vessels due to “wear and tear” caused by years of the normal stressed caused by the heart pulsations and these changes and stiffening becomes more visible after 50 years of age because is normally accompanied with high systolic blood pressure (McEniery, Wilkinson, & Avolio, 2007). Studies done with Chinese populations where a large number of risk factor are not present like hypertension helped to study and identify the role of aging on arteriosclerosis and showed a contrast with other populations were risk factors were present showing that there is actually a normal change in arteries due to age but also risk factor can speed that process. Aging of the arteries is almost exclusive to large elastic arteries; this can be explained by the nature of the arteries where large arteries such as the Aorta are exposed to large amounts of pressure and stretching with every beat causing more damage and changes in structure than small arteries which have to stretch less (Adji, O'Rourke, & Namasivayam, 2011; Viatkevicius, et al., 1993).

Arterial stiffness assessment: Pulse Wave Velocity

Pulse wave analysis (PWA) is a non-invasive technique that detects the early changes in vascular tone through the collection and analysis of blood pressure waveforms. This arterial waveform analysis technique provides an independent assessment of the systemic large and small arterial compliance by obtaining pressure waveforms at the radial artery, which therefore transfers the function and deduces their elastic properties (Oliver & Webb, 2003).

Arterial compliance can be defined as changes in volume for certain blood pressure response. The flexibility of the large arteries are dependent upon their ability to briefly store blood that is ejected by the heart and the small arteries are dependent on their ability to sustain fluctuations in response to blood pressure waveforms generated by each heartbeat. PWA is designed to detect early vascular disease that may be preceded by years of plaque or calcium

buildup in the coronary and other large arteries (Duprez, Buyzere, Clement, & Cohn, 2001; VC Profilor, 2003).

Pulse Wave Velocity is considered as the “gold standard” method for assessing aortic stiffness when measured from the carotid artery to the femoral artery. This method is used largely because is a non-invasive, reproducible, relatively inexpensive, reliable technique and also the ability to predict cardiovascular diseases (Oliver & Webb, 2003; Vlachopoulos, Aznaouridis, & Stefanadis, 2010).

Arterial Stiffness and Physical Activity

The literature shows a vast variety of interventions applied in the laboratory in order to decrease arterial stiffness and the results are as vast as the intervention types. Intervention programs range from pharmaceutical therapies, natural products, nutritional and weight interventions, and the more promising exercise interventions.

Pharmaceutical interventions include mostly hypertensive medicines such as nitrites, beta blockers, ACE inhibitors and some have shown positive results to decrease arterial stiffness but most of these articles were done with limited samples and lack of control and some of these product are only in the testing phase but still there is a promising opportunity from hypertensive medications to have an impact on reducing arterial stiffness (Adji, O'Rourke, & Namasivayam, 2011; Cavalgante, Lima, Redheuil, & Al-Mallah, 2011; Fleenor, 2013). Among these natural products in the testing phase is found curcumin, an ingredient found in Indian spices and that recently showed a decrease in arterial stiffness in mice after a supplementation phase of 4 weeks (Fleenor, 2013). Nutritional intervention can also be found to bring positive results in decreasing arterial stiffness as shown in an intervention study of 6 months that moderate intentional weight

loss has a positive impact in arterial stiffness but the mechanisms behind it need deeper investigation (Barinas-Mitchell, et al., 2006).

Exercise interventions have shown good outcomes in decreasing arterial stiffness when the correct modalities are applied but overall increased physical activity showed a relation with decreased values of arterial stiffness. According to Otsuki, et. al. (2007), there are different adaptations to exercise depending if it is endurance training or strength training. Endurance trained males showed lower values of arterial stiffness and strength trained males showed higher arterial stiffness values as compared with sedentary, healthy age matched individuals. Therefore we can conclude that resistance training increases arterial stiffness while endurance training decreases arterial stiffness (Otsuki, et al., 2007). Another article showed that intensity also plays a role in the adaptations of the cardiovascular system and more specifically arterial stiffness. The authors also concluded that moderate exercise intervention reduces central arterial stiffness but has no changes in peripheral arteries. This study showed that there are changes in artery diameter but this does not reflect a change in arterial stiffness (Hayashi, Sugawara, Komine, Maeda, & Yokoi, 2005).

It has been demonstrated that there is a normal progressive increase in arterial stiffness with age that is similar in males and females. Sedentary individuals tend to show an inverse relation between arterial stiffness and aerobic capacity without necessarily have a difference in systolic blood pressure (Viatkevicius, et al., 1993). Another study with female population also showed that with age the same changes in arterial stiffness are present; increase stiffness in central arterials but not in peripheral arteries but these increase in central arterial stiffness is attenuated in the presence of high physical activity (Tanaka, DeSouza, & Seals, 1998). Aerobic physical activity has shown to be an important factor in the speed of the development of central

arterial stiffness in both female and men and proved to attenuate the normal progression of arterial stiffness caused by age.

Whole body vibration (WBV) training is a new training technique that already showed positive results in decreasing acutely arterial stiffness. The use of WBV as an aid to decrease arterial stiffness is not widely spread yet but it has been effective in decreasing arterial stiffness in different populations like healthy sedentary men, young overweight/obese women, and even clinical subject presenting prehypertension and hypertension but further research is needed to understand the mechanisms behind this training method and the reduction of arterial stiffness and the creation of specific training protocols to ensure the most effective results(Figueroa, Kalfon, Madzima, & Wong, 2013; Figueroa, et al., 2012; Otsuki, Takanami, Aoi, Kawai, Ichikawa, & Yoshikawa, 2008). Otsuki, et al. (2008) was the first author to report an acute reduction in arterial stiffness after a bout of WBV exercise in humans. It was reported that after 10 sets of one minute static squat on the vibration plate at a frequency of 26 hertz; there was a reduction in arterial stiffness as compared with the control group which went through the same procedures without the vibration stimuli and the effect lasted for 40 minutes after the vibration ended. Figueroa, et al., (2011, 2012, 2013) in a series of studies has demonstrated some of the effects of WBV on hemodynamic responses acutely and after training. Some of the findings reported are that WBV decreases leg arterial stiffness and reduces the acute increase in augmentation index caused by static squat exercise. After 10 sets of one minute static squat with WBV at a frequency of 40 Hz the wave reflection was decreased as compared with no WBV during squat demonstrating a local effect on leg arterial stiffness after 15 and 30 minutes after ending the exercise (Figueroa et.al., 2011).

Figueroa et al., (2012, 2013) also investigated the effects of WBV training in two different long term studies; the first one investigated the effects on blood pressure and sympathovagal balance on overweight women. It was reported that after six weeks of WBV training consisting on static, dynamic squatting and calf raises on the vibration plate three times per week at frequencies 25-30hz there was a decrease in systemic arterial stiffness and aortic systolic blood pressure (Figueroa et al., 2012). The second study examined the effects of a 12 week WBV training program on arterial stiffness of postmenopausal women with prehypertension and hypertension finding also positive results reducing systemic and leg arterial stiffness as well as muscle strength improvements after the 12 week training period (Figueroa et al., 2014).

Conclusion

After reviewing the available literature regarding arterial stiffness we can conclude that research prove the importance of arterial stiffness as a cardiovascular risk factor and a predictor of future cardiovascular and cerebrovascular diseases. The use of Pulse wave velocity as a reliable, accessible and noninvasive tool to measure arterial stiffness has been validated over the years. Pulse wave velocity measurement is a good predictor of cardiovascular disease (Oliver & Webb, 2003; Vlachopoulos, Aznaouridis, & Stefanadis, 2010). Aging is a primary factor in arterial stiffness especially in large arteries but several factors like obesity and sedentary lifestyle contribute to the progression of arterial stiffness creating a risk for cardiovascular disease (MCEniery, Wilkinson, & Avolio, 2007; Tanaka, DeSouza, & Seals, 1998). Different interventions have shown positive results to decrease arterial stiffness but aerobic exercise has been proven to decrease in several studies not only an acute decrease but also attenuation over time of the normal progressive degeneration seen with age. WVB is a great training option to

reduce arterial stiffness for general populations and even more for specific population that cannot perform the recommended levels of physical activity (Adji, O'Rourke, & Namasivayam, 2011; Cavalgante, Lima, Redheuil, & Al-Mallah, 2011). There is a need for more research in this topic to further investigate and understand the physiological mechanisms involved in the decrease of arterial stiffness due to Whole Body Vibration training and the difference that varying protocols such as amplitude and frequency can create in the effectiveness of the training to reduce arterial stiffness (Figueroa, Kalfon, Madzima, & Wong, 2013; Figueroa, et al., 2012; Otsuki, Takanami, Aoi, Kawai, Ichikawa, & Yoshikawa, 2008).

CHAPTER III

METHODOLOGY

The purposes of the study were to examine the acute effects of dynamic whole body vibration (WBV) training on small and large arterial stiffness, to examine the effects of different frequency and amplitude protocols in heart rate (HR), systolic and diastolic blood pressure, mean arterial pressure (MAP), cardiac output (CO), and stroke volume (SV) and identify the best WBV protocol to decrease acutely arterial stiffness. The methodology of the present study is presented in this chapter.

Setting

The study procedures took place in the Biomedical Research building 2, #1.316.

Subjects

Sixteen sedentary or recreationally active males aged 20-39 (age ave= 24.13, n=16) participated in this study. Sedentary or recreationally active was defined as no regular physical activity (less than three times per week) for six months prior to recruitment. Participants were recruited from the University of Texas-Brownsville and the Cameron County community. Each subject completed the informed consent, PAR-q questionnaire, and pre-testing prior to participation in the study as recommended by ACSM. Subjects were informed on the procedures that were to take place on their scheduled day of testing. The study was approved by the University of Texas-Brownsville Institutional Review Board for Human Subjects.

Inclusion criteria

- Only adult males aged 18 – 40 were included in the study.
- Subjects with no history of cardiovascular diseases.

- Subjects with no injuries or diseases which prevented physical activity.
- Subjects, who are considered sedentary or recreationally active.

Exclusion criteria

- Subjects presenting high blood pressure (>140/90mmHg).
- Subjects with injuries or diseases preventing them from completing the study procedures.
- Subjects, who followed training programs or performed regular physical activity.
- Subjects, who were taking medication that could affect the hemodynamic responses.

Recruitment

Subjects were recruited from the University of Texas at Brownsville and Cameron County community via flyers with detailed information about participating in a Whole Body Vibration study posted on and off campus and word of mouth. Participation was voluntary and participants were able to withdraw from the study at any time. Interested subjects were contacted via email or phone to set up meetings at the University of Texas at Brownsville Biomedical Research Building 2 laboratory 1.316.

Study Procedure

The length of the study was five 60-70 min/session following a fasting for at least eight hours. Each session was separated by at least 48 hours. The first day included signing an informed consent form and completing the physical activity readiness questionnaire (PAR-Q). After completing the paperwork, anthropometric measures that include height and weight were recorded and familiarization with the testing procedures took place. Subjects' questions were answered and the correct technique, tempo, cadence, and proper movement for the squat exercise

was explained and demonstrated. Prior to each session, subjects' pre-exercise small and large arterial stiffness (PWA), resting heart rate (RHR), resting systolic and diastolic blood pressure (SBP and DBP), pulse pressure (PP), stroke volume (SV), stroke volume index (SVI), systemic vascular resistance (SVR) and total vascular impedance (TVI) was assessed and recorded. After completion of baseline testing and questionnaires, subjects were randomly assigned to either high amplitude-high frequency (HAHF), high amplitude- low frequency (HALF), low amplitude-low frequency (LALF), or low amplitude-high frequency (LAHF) for the arrangement of following 4 sessions and finally a control session took place with the exact same procedures as the exercise conditions but without the application of whole-body vibration.

Each session was performed on the whole body vibration platform at a set air displacement depending on the subject's body weight following the user guidelines of the training equipment. Every session consisted of 10 sets of dynamic squats with movement starting at 180 degrees (180 being full extension) and flexing down until 120 degrees. Each repetition took 3 seconds to control the repetitions and speed of movement using a Seiko digital metronome (Seiko pocket –size digital DM21-440). Each set lasted 60 seconds with a 60 seconds rest period between sets.

Subjects arrived to the laboratory in the morning of testing and had the pre-workout arterial stiffness and hemodynamic assessment completed. Then the previously randomized exercise protocol started and lasted approximately 20 minutes. Immediately after completion of the last set; arterial stiffness, HR, systolic and diastolic blood pressure and mean arterial pressure were assessed. The same assessment was repeated at 5, 15 and 30 minutes after the session while resting in a quiet room.

The total time requirement for the exercise sessions was approximately 1 hour per session and 1.5 hrs for the first session.

Equipment

Pulse Wave Analysis

Arterial stiffness was measured indirectly using HDI/PulseWaveTM CR-2000 Research Cardio Vascular Profiling System (Hypertension Diagnostics, Inc. Eagan, MN, USA). Following an eight hour fast, the large and small artery elasticity was measured by a hand held sensor to non-invasively track the speed of blood flow (meters per second).With the right forearm resting in a supine position, an Arterial PulsewaveTM sensor was placed on the skin directly over the radial artery at the point of the strongest pulse. The CV Profiling System reports an individual's HR, BP, mean arterial pressure, pulse pressure, pulse rate, stroke volume, cardiac output, large and small arterial elasticity, vascular resistance, and vascular impedance by non-invasively measuring 30 seconds of blood pressure waveforms. This noninvasive approach was repeated and done as a pre and post assessment in the study.

Power Plate

The whole body vibration machine (Power Plate Pro 5.0, Power Plate North America, Inc. Irvin, CA, USA) sends an external vibratory stimulus to enter the body. The localized muscle, hands and feet receive the stimuli by standing on a vibrating platform and/or gripping a handle bar and/or placing on the vibrating platform. The external vibration stimuli varied in frequency and amplitude depending session. Air displacement was in accordance with the subject's body weight as indicated in the user's manual.

Statistical Analysis

Repeated measures ANOVA (time [pre-exercise, immediately after exercise, post 5 min, post 15 min and post 30 min] x condition [the 5 different conditions]) were used to detect the differences in the dependent variables tested. Bonferroni's post-hoc tests were performed to determine further differences when significant main effects were found. The level of statistical significance was set at $P<0.05$ and data was expressed as means ±SE. The statistical analyses were undertaken by using SPSS for Windows (SPSS Inc., Chicago, IL).

CHAPTER IV

RESULTS

The purposes of the study were to examine the acute effects of dynamic whole body vibration (WBV) training on small and large arterial stiffness, to examine the effects of different frequency and amplitude protocols in heart rate (HR), systolic and diastolic blood pressure, mean arterial pressure (MAP), cardiac output (CO), and stroke volume (SV) and identify the best WBV protocol to decrease acutely arterial stiffness. The methodology of the present study is presented in this chapter. After testing all the subjects the following data was collected.

Subjects Characteristics

Sixteen sedentary or recreationally active males aged 20-39 (age ave= 24.13, n=16) participated in this study. Sedentary or recreationally active was defined as no regular physical activity (less than three times per week) for six months prior to recruitment. Table 1 shows the participants anthropometric measures.

Table 1 : SUBJECTS' ANTHROPOMETRICS

Variable	**Value**
Age (yr)	24.1 ± 1.1
Height (in)	69 ± 0.5
Weight (lb)	193 ± 8.3
BMI	28 ± 1.1

Values reported as means ±SE

Cardiovascular Response

Systolic Blood Pressure (SBP)

For SBP, there was no significant condition main effect, but a significant condition*time interaction (P=0.014) and a time (P=0.01) main effect were detected. Follow-up analyses showed that SBP was significantly different between time point pre and post 0 min, post 0 min was significantly different from all other time points, and post 5 min was significantly different from post 30 min (Figure 1).

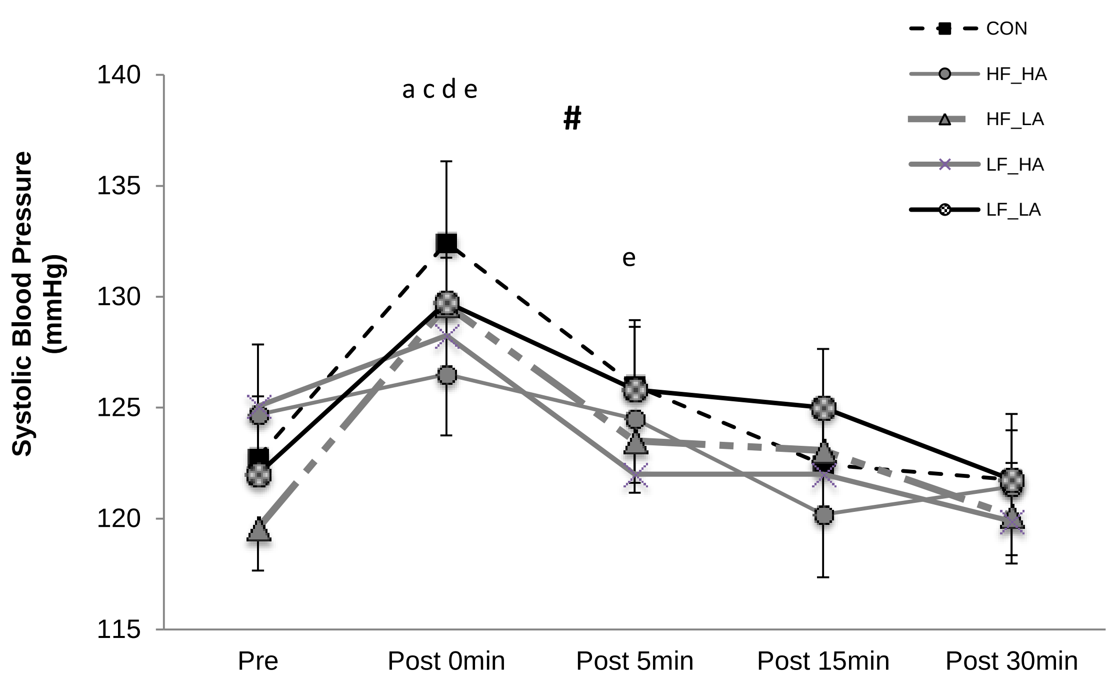

Figure 1. Systolic Blood Pressure values before and after exercise. [a] Represents significant difference(P<0.05) from pre. [b] Represents significant difference (P<0.05) from post 0 min. [c] Represents significant difference (P<0.05) from post 5 min. [d] Represents significant difference

(P<0.05) from post 15 min.[e] Represents significant difference from post 30 min. # Represents significant Time*Condition interaction. Values reported as Mean ± SE.

Diastolic Blood Pressure (DBP)

For DBP, there was no significant condition* time interaction and no significant main effect for condition, but there was a significant time main effect for DBP (P=0.009). Follow up analysis showed that post 0 min to be significantly different from post 5 min (Figure 2).

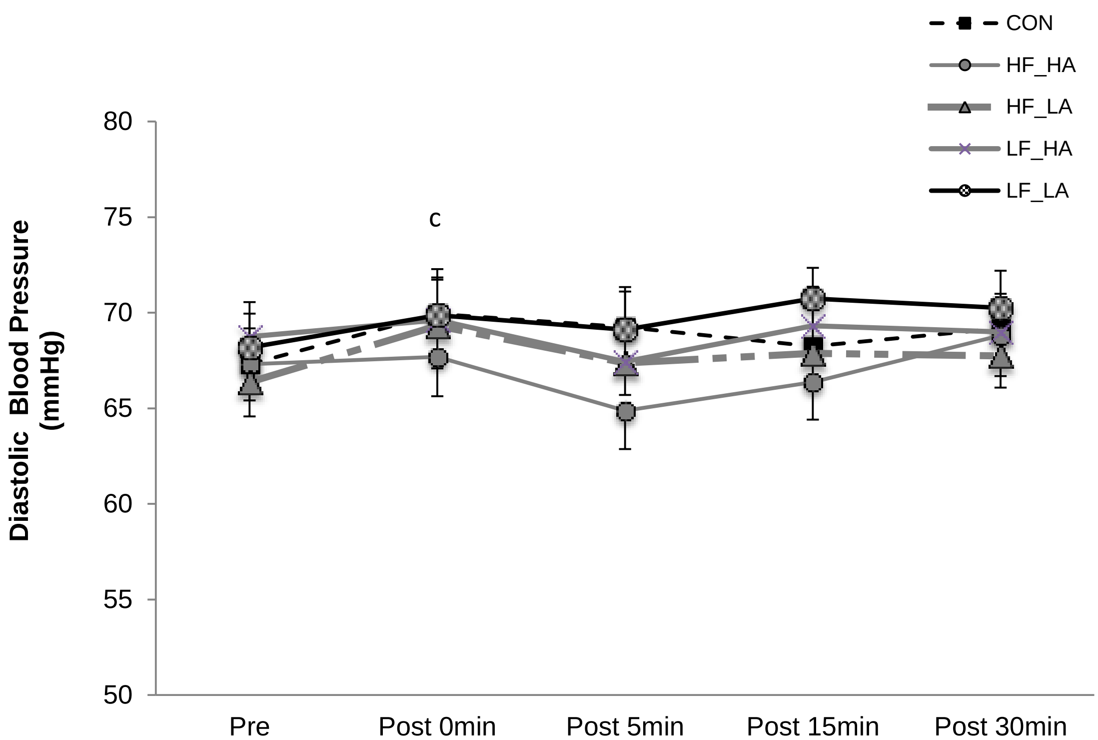

Figure 2 Diastolic Blood Pressure values before and after exercise. [c] Represents significant difference (P<0.05) from post 5 min. Values reported as Mean ± SE.

Mean Arterial Pressure (MAP)

For MAP, there was no significant condition main effect, but a significant condition*time interaction (P=0.007) and a time (P=0.001) main effect were detected. Follow-up analyses showed that MAP was significantly different between time point post 0 min and post 15 min (Figure 3).

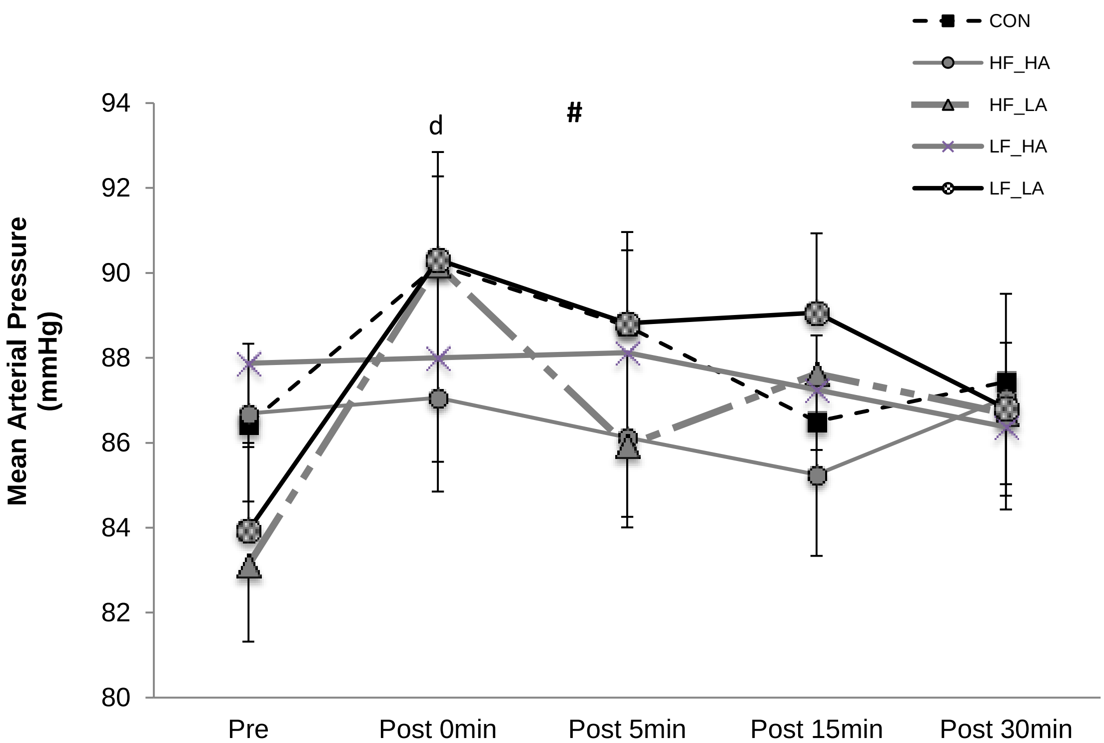

Figure 3. Mean Arterial Pressure values before and after exercise. [d] Represents significant difference (P<0.05) from post 15 min. # Represents significant Time*Condition interaction. Values reported as Mean ± SE

Pulse Pressure (PP)

For PP, there was no significant condition* time interaction and no significant main effect for condition, but there was a significant time main effect for Pulse Pressure (P=0.001). Follow up analysis showed that time post 0 min and post 30 min to be significantly different from all other time points and post 5 min showed to be significantly different from post 15 min as well (Figure 4).

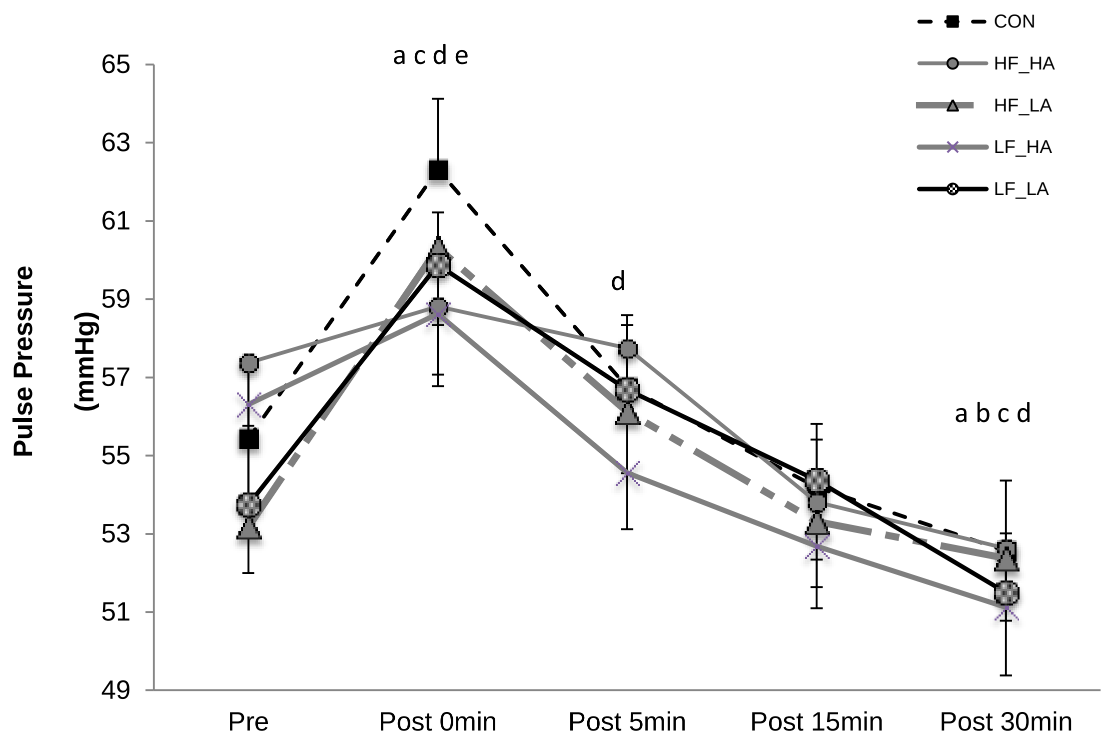

Figure 4. Pulse Pressure values before and after exercise. [a] Represents significant difference (P<0.05) from pre. [b] Represents significant difference (P<0.05) from post 0 min. [c] Represents significant difference (P<0.05) from post 5 min. [d] Represents significant difference (P<0.05) from post 15 min. [e] Represents significant difference from post 30 min. Values reported as Mean ± SE.

Heart Rate (HR)

For HR, there was no significant condition* time interaction and no significant main effect for condition, but there was a significant time main effect for heart rate (P=0.045). Follow up analysis showed time post 15 min to be significantly different from post 30 min (Figure 5).

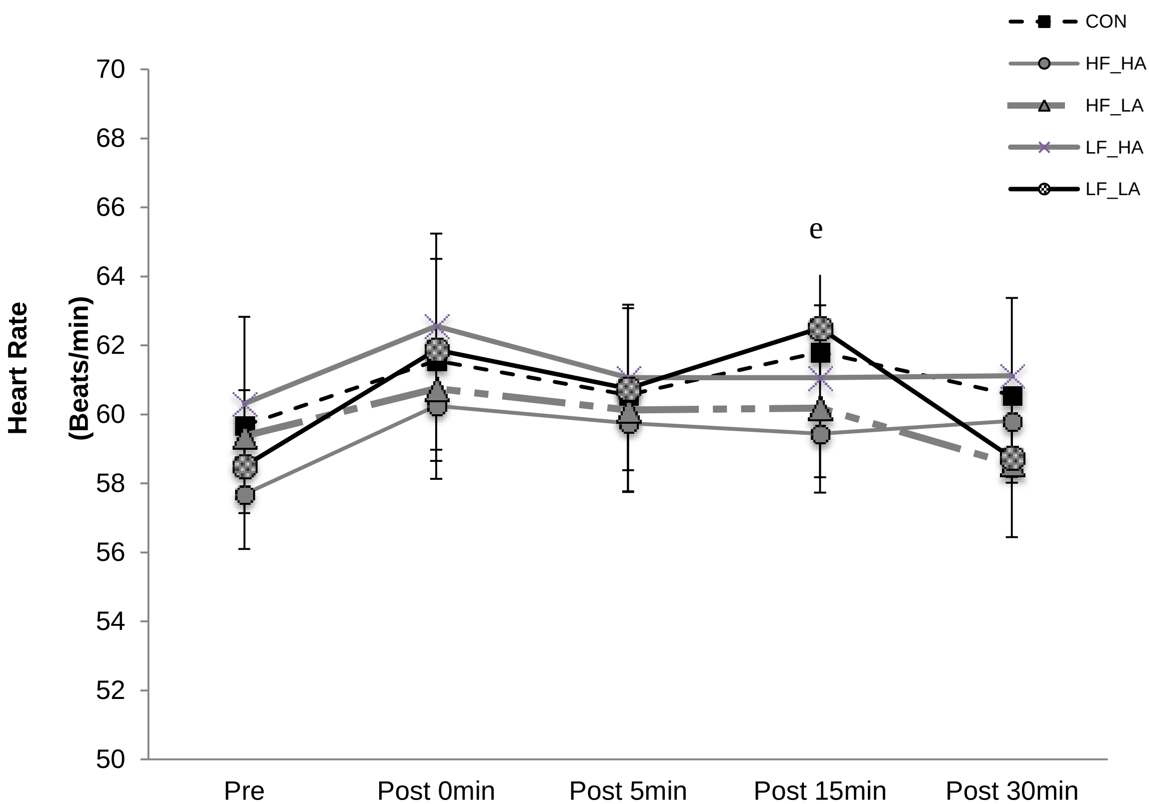

Figure 5. Heart Rate values before and after exercise. [e] Represents significant difference from post 30 min. Values reported as Mean ± SE.

Estimated Cardiac Ejection Time (CET)

For CET, there was no significant condition* time interaction and no significant main effect for condition or time (Figure 6).

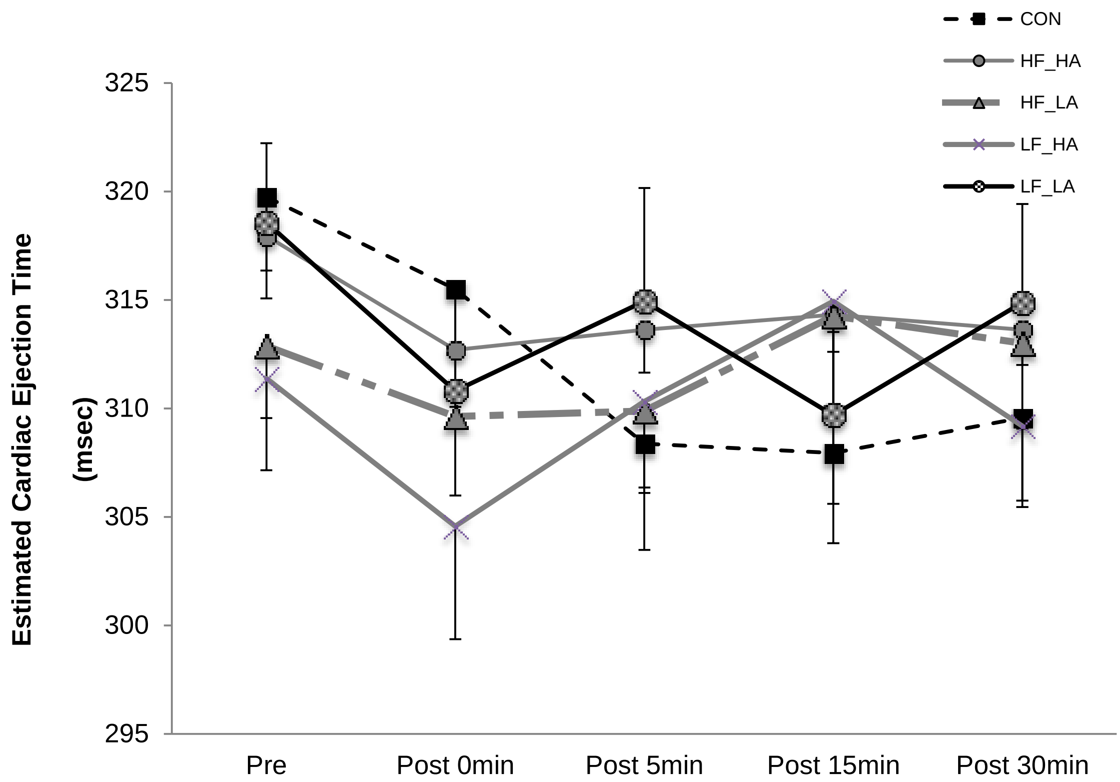

Figure 6. Estimated Cardiac Ejection Time values before and after exercise. Values reported as Mean ± SE.

Stroke Volume (SV)

For SV, there was no significant condition* time interaction and no significant main effect for condition, but there was a significant time main effect for SV (P=0.039). Follow up analysis showed no significant difference between time points (Figure 7).

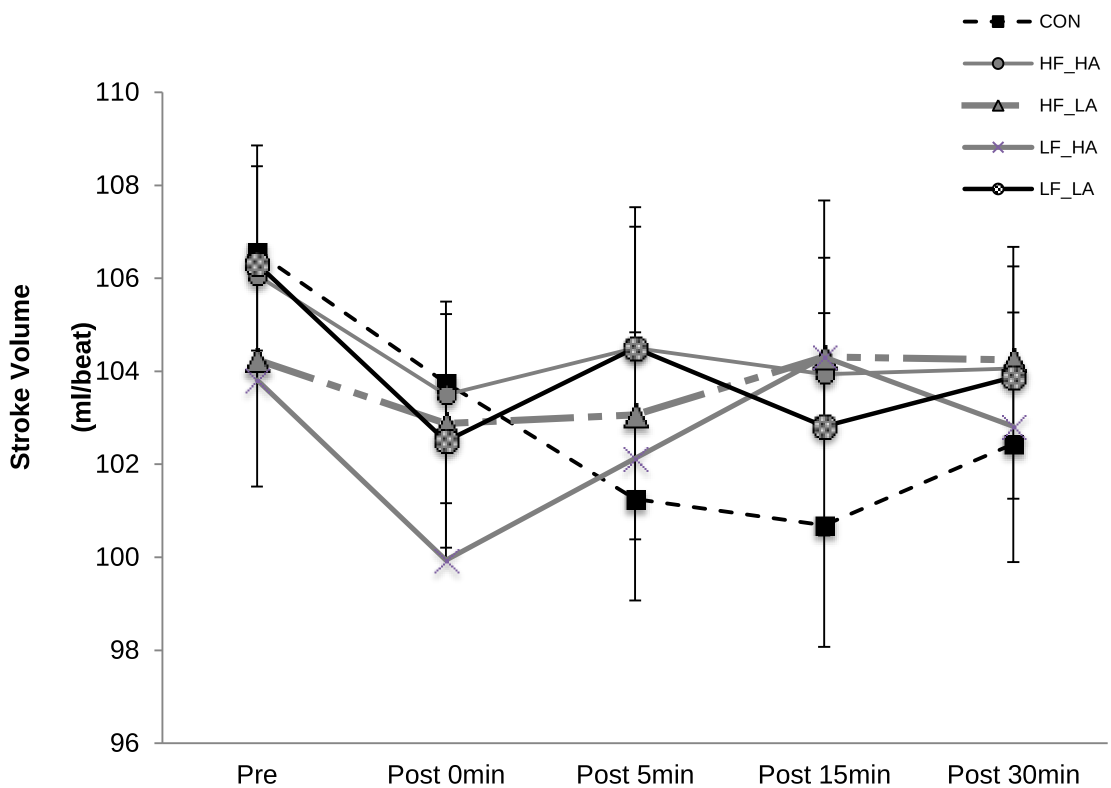

Figure 7. Values for stroke volume before and after exercise. Values reported as Mean ± SE.

Stroke Volume Index (SVI)

For SVI, there was no significant condition* time interaction and no significant main effect for condition, but there was a significant time main effect for Stroke Volume (P=0.036). Follow up analysis showed no significant difference between time points (Figure 8).

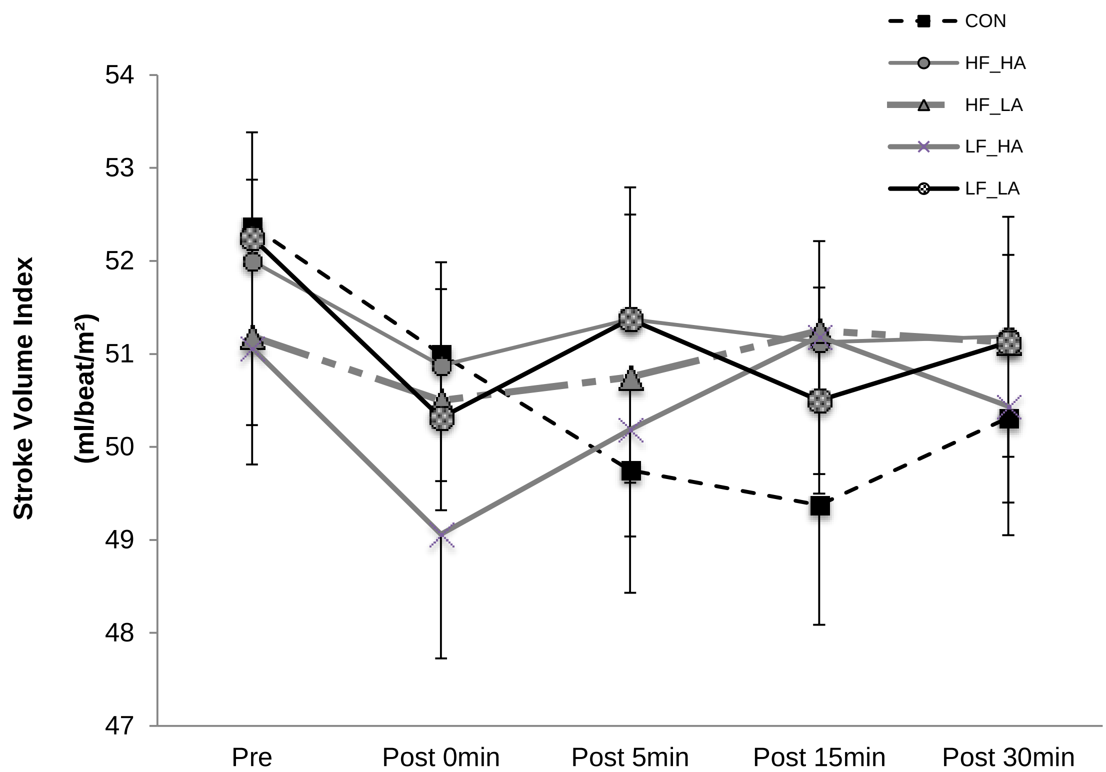

Figure 8. Values for Stroke Volume Index before and after exercise. Values reported as Mean ± SE.

Cardiac Output

For CO, there was no significant condition* time interaction and no significant main effect for condition or time (Figure 9).

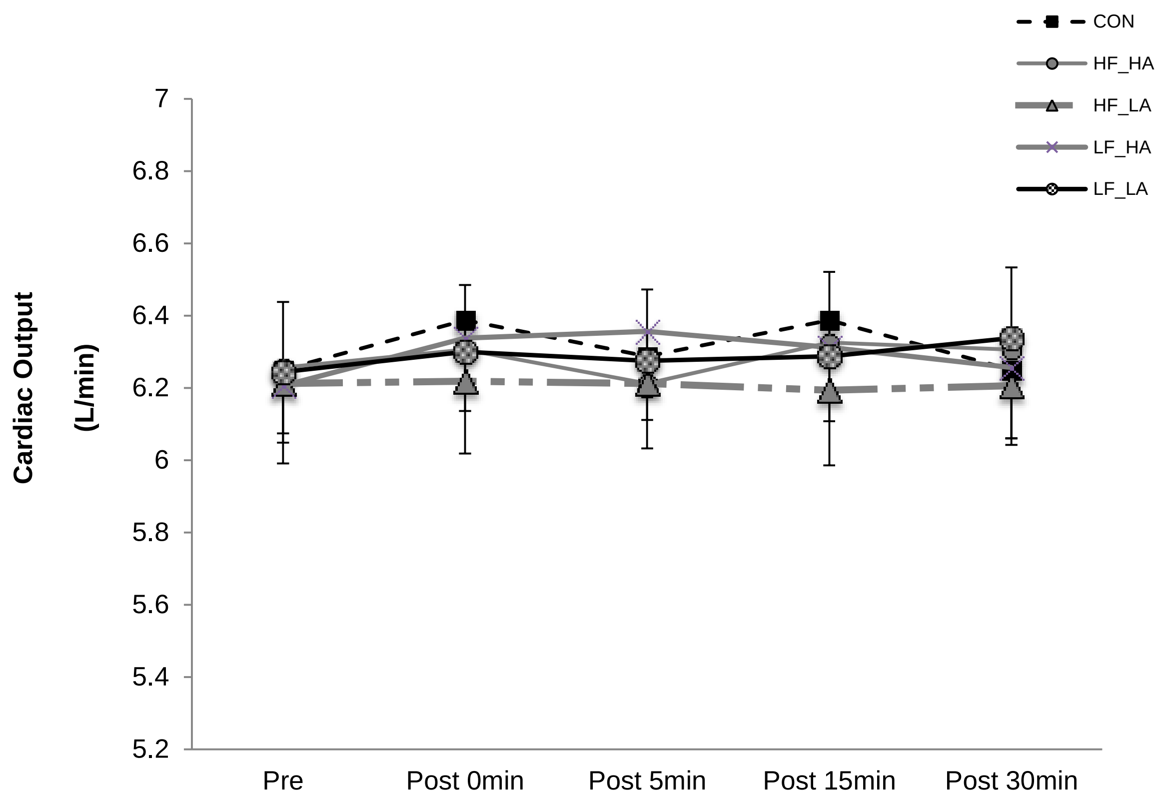

Figure 9. Cardiac Output values before and after exercise. Values reported as Mean ± SE.

Large Arterial Elasticity Index (LAEI)

For LAEI, there was no significant condition* time interaction and no significant main effect for condition, but there was a significant time main effect for LAEI (P=0.010). Follow up analysis showed no significant difference between time points (Figure 10).

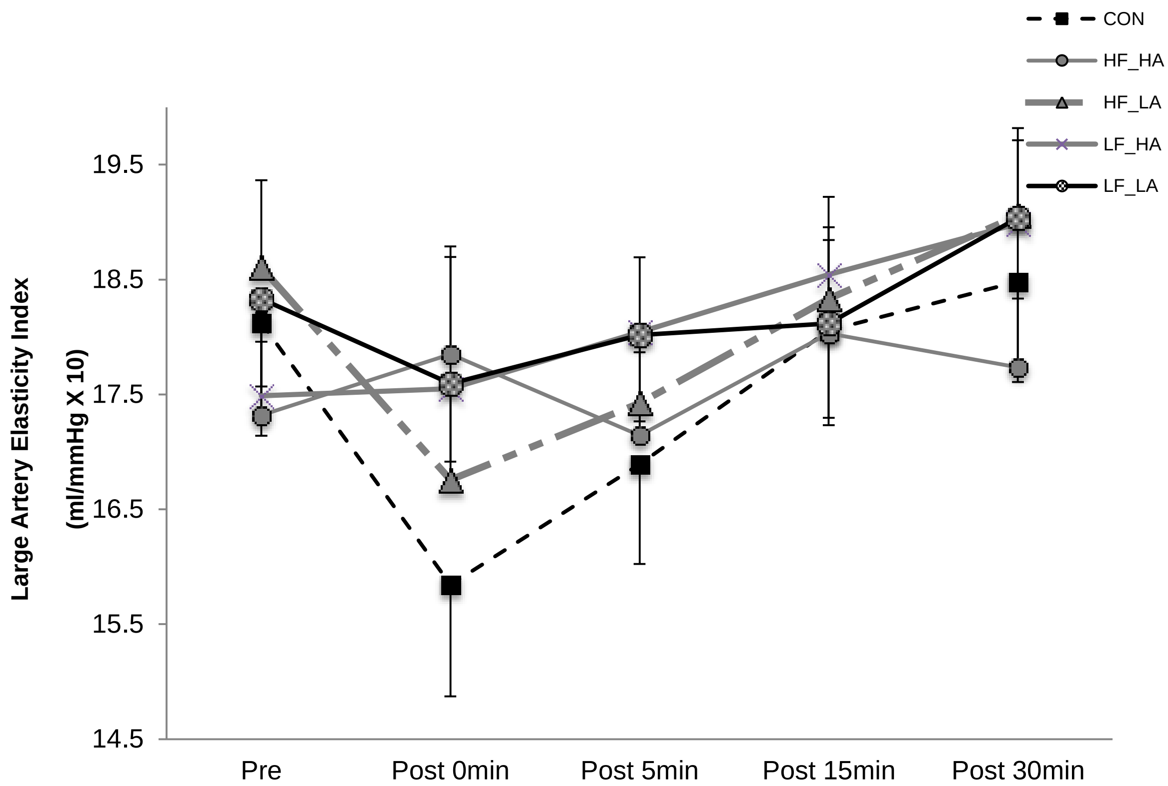

Figure 10. Large Artery Elasticity Index values before and after exercise. Values reported as Mean ± SE

Small Artery Elasticity Index (SAEI)

For SAEI, there was no significant condition* time interaction and no significant main effect for condition, but there was a significant time main effect for SAEI (P=0.040). Follow up analysis showed time point Pre exercise to be significantly different from Post 5 min time points (Figure 11).

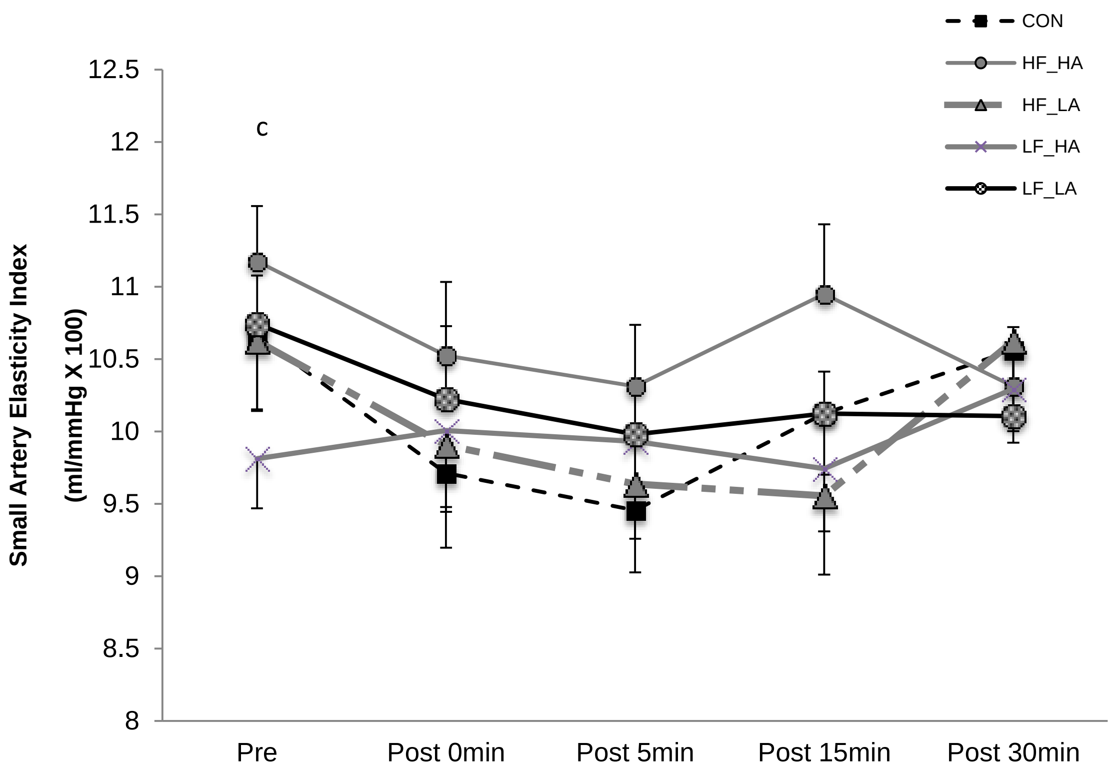

Figure 11. Small Artery Elasticity Index values before and after exercise. [c] Represents significant difference from time point post 5 min. Values reported as Mean ± SE.

Systemic Vascular Resistance (SVR)

For SVR, a trend (P=0.07) was found for condition*time interaction. No significant main effect was found for time or condition (Figure 12).

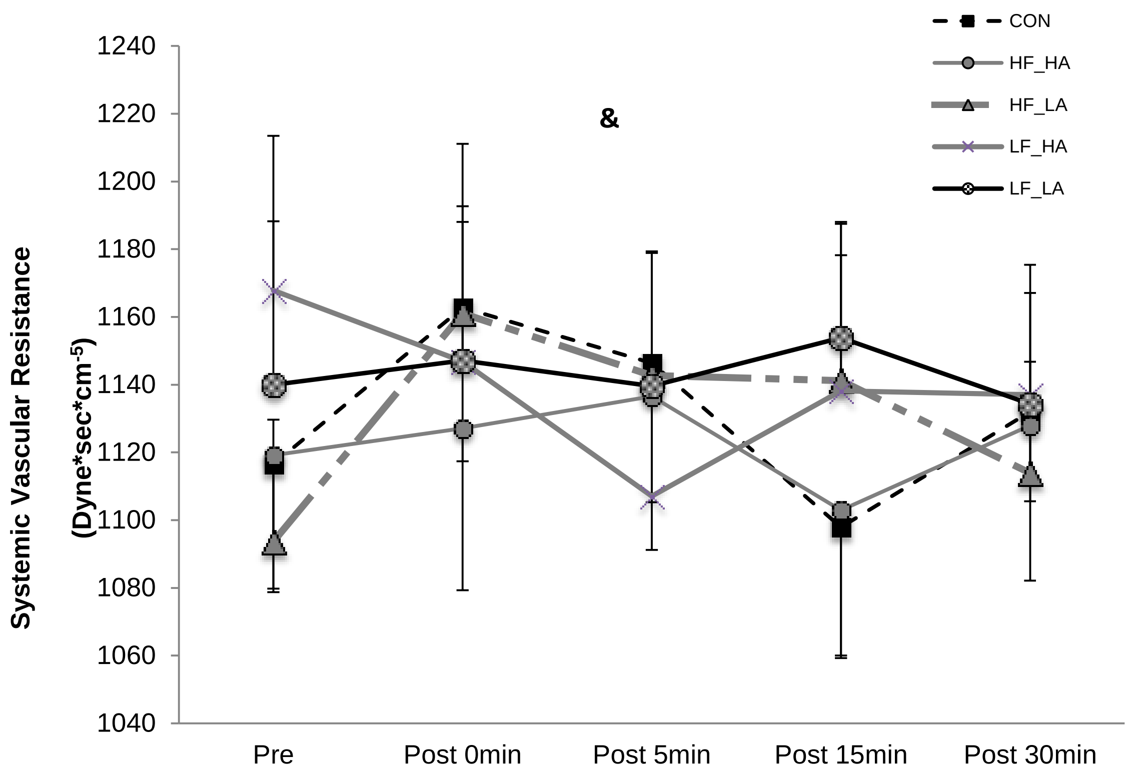

Figure 12. Systemic Vascular Resistance values before and after exercise. & Represents a trend for Time*Condition interaction. Values reported as Mean ± SE.

Total Vascular Impedance (TVI)

For TVI, a trend was found for condition * time interaction (P=0.067). No main effect was found for condition, but a time main effect was found (P=0.001). Follow up analysis showed time point post 5 min to be significantly different from time point post 15 min (Figure 13).

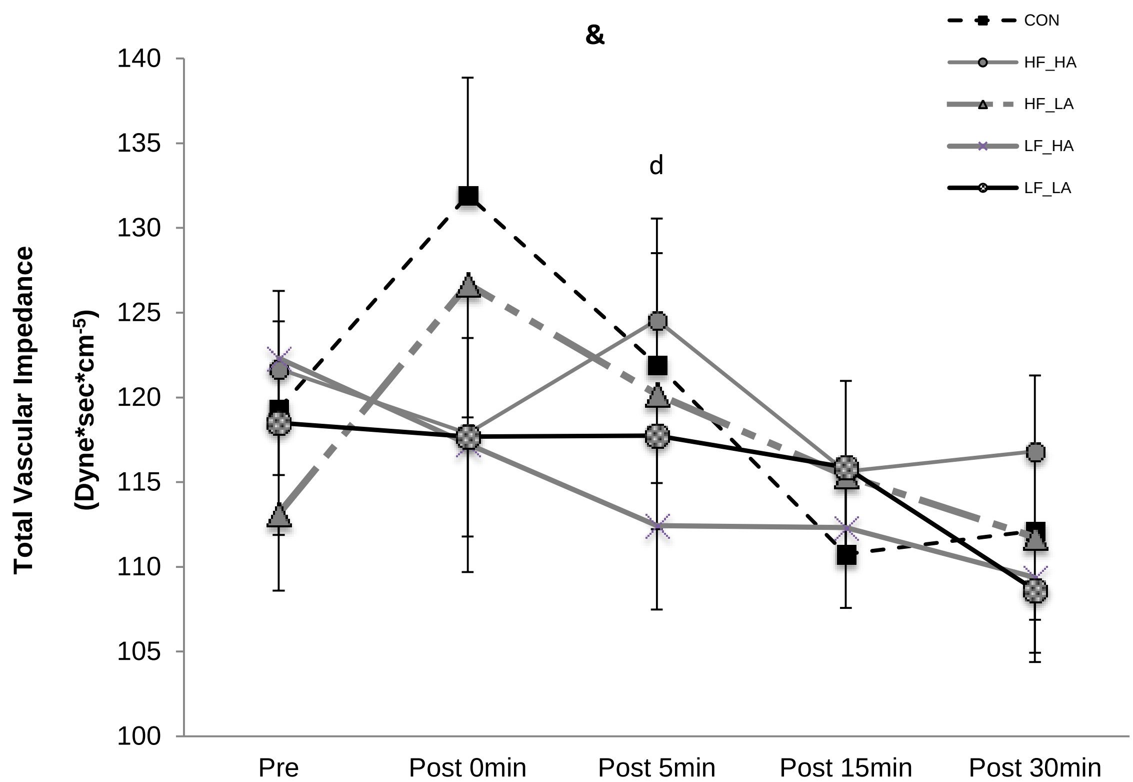

Figure 13. Total Vascular Impedance values before and after exercise. [d] Represents significant difference from time point post 15 min. & represents trend for time*condition Interaction. Values reported as Mean ± SE.

CHAPTER V

DISCUSSION

The main purpose of this study was to compare the acute effects of different vibration settings on arterial stiffness and hemodynamics after a session of whole-body vibration training and to investigate the setting which produced the best outcome in decreasing arterial stiffness. The key finding in this investigation is that different vibration settings when using whole-body vibration training did not seem to produce different adaptations on particular hemodynamic markers after a single bout of training in adult sedentary males. Many time effects were found, meaning that exercise with the different vibration settings, as well as the control, have similar effect of hemodynamics at different time points. However, time*condition interactions that were found on some hemodynamic and cardiovascular indicators may indicate that the different vibration settings used for whole body vibration training during the lower body exercise may produce different responses.

Blood Pressure

Some studies have reported a hypotensive effect after a single bout of aerobic and even after a single bout of resistance training at different intensities (Cornelissen and Fagard, 2005; Forjaz et al., 2004; Gomez-Cardozo et al., 2009; Rezk et al., 2006). The present findings do not agree with the previous findings reported in the aforementioned studies. The differences between findings might be due to the different characteristics of the population utilized in the different studies; specifically the present study utilized normotensive subjects in contrast with clinical patients with hypertension in other studies, which could have an important role on facilitating and enabling the hypotensive effect found after the bout of exercise (Cornelissen and Fagard,

2005; Gomez-Cardozo et al., 2009). Another possible responsible factor for the inconsistencies in findings could be the type of exercise and intensity used in this study. The present study used dynamic squat, which is a resistance type of exercise as compared to aerobic exercise used in some of the studies and the intensity of the exercise was lower than the reported in the other studies (Forjaz et al., 2004; Rezk et al., 2006). It was concluded by Forjaz et al., (2004) that more intense and prolonged exercise produced greater hypotensive effects while studying aerobic exercise during 45 min at different exercise intensities. On the other hand, the results that were reported in this study are in accordance with the results reported by Figueroa, Vicil and Sanchez-Gonzalez (2011) which also reported an increase in blood pressure after 5 min of whole-body vibration exercise following a single bout of 10 min intermittent static squats with whole body vibration at a frequency of 40 Hz which is a very similar procedure than the one used in the present study.

The time*condition interaction detected for systolic blood pressure (SBP) measurements shows that the effect of the vibration protocol used affected the SBP responses. High amplitude seems to have an important role in SBP responses. For the present study, the vibration protocols including high amplitude (high frequency- high amplitude and low frequency-high amplitude) attenuated the increase in blood pressure seen after the exercise as compared to the other protocols using low amplitude and control. These vibration protocols also created an overall decrease in values after 30 min when compared to pre exercise values.

Pulse pressure (PP) is a representation of the force produced by the heart every time it contracts; in simple terms, PP is the SBP or pressure during contraction minus the diastolic blood pressure or pressure during relaxation. PP is influenced by the stroke volume or amount of blood been ejected every contraction and the compliance or elasticity mainly in the aorta therefore the

increase on PP could be influenced by decreases in elasticity of the aorta (Klabunde,R.E. et al., 2014). Statistical differences were found between post 0 min and all others points as well as post 30 min with all other time points. As we can see in figure 4, there is a visible increment at post 0 min as compared to all the other points; the same way time point post 30 min is visibly lower to all the other time points on the graph.

Hemodynamic Response

This study found no statistical differences between conditions for heart rate (HR), estimated ejection time (EET), stroke volume (SV), and cardiac output (CO). No condition*time interactions were found for any of these variables and there was a time effect found for HR between the time points post 15 min and post 30 min as well as a time effect for SV but follow-up analysis showed no difference between time points. The lack of difference between conditions, time points and lack of condition*time interaction in these hemodynamic responses might be due to the low intensity of the exercise, low duration and rest between sets. The findings in this study are similar to those found by Otsuki at al., (2008) which used the same number of set and time duration while doing static squat and found no significant differences on heart rate. Studies by DeVan et al., (2005) and Rezk et al., (2006) reported acute increases in HR after a single session of resistance training. The discrepancies between our results and those presented in these studies might be due to the higher intensity of the workout; in the previously mentioned studies a full body workout was used as intervention; in one case with 1 set of 9 different exercises until exhaustion and in the other case also a full body workout consisting of 6 different exercises for 3 sets of 20 repetitions at a workload of 40% of 1RM or 3 sets of 10 repetitions at a workload of 80% 1RM. The authors concluded that HR increases were controlled by an increase in sympathetic and decrease of parasympathetic modulation of the heart and these

activated in order to control the reduction in blood pressure seen in their cases that is also important to emphasize that this effect was not seen in our study.

Arterial Elasticity

The results on large arterial elasticity (LAEI) and small arterial elasticity (SAEI) do not match the findings reported by previous research examining whole body vibration training. Otsuki et al., (2008) demonstrated that arterial elasticity increased acutely and remained elevated 20 and 40 minutes after exercise a session of intermittent static squat using whole body vibration. The methodology in both studies was comparable, but the apparatus used to record the data was different, which could be the responsible factor creating the discrepancy found between the results. Otsuki et al., (2008) utilized a method called pulse wave velocity (PWV), which consists of measurement of the time delay between the pressure waves traveling from the heart to the brachial artery and from the heart to the post-tibial artery; the values reported using this method would be directly affected by changes in arterial elasticity of the legs. In the present study, a pulse wave analysis method using the radial artery was utilized therefore, in order to find changes in the wave form analysis the effect needed to be systemic and not only local. Another study by Figueroa et al., (2011) also reported a decrease on arterial stiffness after a 10 min bout of intermittent static squat on whole body vibration platform. In this case, the author discovered that the increment in arterial elasticity was due to a localized effect. The author found that after the exercise measurements of PWV differed depending on the measurement utilized; femoral-ankle PWV was decreased and the effect lasted after 30 min post exercise while measurements of carotid- femoral and brachial-ankle PWV did not show any changes after exercise with whole body vibration. Once again in both of these two studies (Figueroa et al., 2011 and Otzuki et al., 2008) PWV which reflected directly the effect of changes in arterial elasticity on specific

segments of the body. Therefore, the use of equipment that did not allows us to account for the local effects of whole body vibration on arterial stiffness could have been a reason and might explain the lack of response seen by the results on this study. As for the effect of the different vibration amplitudes and frequencies we found some differences between conditions, but not large enough to be statistically significant and this might be due to the sample size and the number of variables and time points considered in this study. Otsuki et al., (2008) utilized a vibration frequency of 26 Hz while Figueroa et al., (2011) used a frequency of 40 Hz. Figueroa et al., deducted that the difference in vibration protocols utilized among the studies ultimately could have created discrepancies in the results due to the impossibility of higher frequencies to travel through the trunk/upper body avoiding the effect of the vibration on the Aorta. Otsuki et al., (2008) which utilized lower frequency (26Hz) in his study as compared to 40 Hz on Figueroa et al., (2011) study reported a longer lasting effect on decreasing arterial stiffness using the same protocol. In the present study, low frequency combined with high amplitude was the condition which showed the larger increase after 30 min as compared to pre exercise on LAEI and SAEI.

The present study measured arterial elasticity via PWV using the radial artery wave form to predict large and small arterial elasticity as well as other hemodynamic markers, therefore, it is reasonable to assume that if the present study used an apparatus with the ability to measure the localized changes on the lower body arterial elasticity, the results could have reflected differences the difference in peripheral arterial elasticity which were more pronounced on the lower body and this way report results that could go in accordance with the results reported in the literature. Another speculation involved in the use of brachial wave form analysis is that in order for a positive response to be observed while doing lower body exercises, the systemic changes had to be larger because the local effect caused by the WBV training in the lower body

is difficult to be assessed using this technique. The acute decrease in arterial elasticity found in this study is in the other hand in agreement with those found by DeVan et al., (2005) which reported an acute decrease in arterial elasticity after a bout of full body resistance training with values returning to baseline levels in less than 60 min. the exercise intervention consisted of one set of 9 exercises at 75% of 1 RM until exhaustion and measuring arterial elasticity using ultrasound and applanation tonometry technique. The reported decrease in arterial stiffness was speculated to be related with changes on blood pressure but no changes were found on mean arterial pressure. The authors also speculated that the changes found could be an effect of vasoconstriction caused by production of epinephrine.

Systemic Vascular Resistance, Mean Arterial Pressure and Total Vascular Impedance

Systemic Vascular Resistance (SVR) is defined as the total resistance to blood flow offered by the systemic vasculature with the exclusion of the pulmonary vasculature, in other words, the resistance that the heart has to overcome in order to circulate blood through the organism (Fuster, V., Alexander, R.W., O´Rourke, R.A., 2004). The changes found in the present study between condition and time for SVR parallel with that has shown that some studies which report changes in systemic vascular resistance after a bout of resistance exercise either showing a small increment to compensate for a decrease in cardiac output and production of epinephrine or a localized reduction due to local vasodilator production like Nitric Oxide. The studies also found that these changes are also dependent of intensity and time of exercise (Forjaz et al., 2004; Rezk et al., 2006; Cornelissen and Fagard, 2005; Goto, K., Takamatsu, K.,2005). Also the acute increase in vascular resistance could explain the acute increase found in mean arterial pressure (MAP) as well as the time*condition interaction. MAP is almost directly proportional to vascular resistance and cardiac output; therefore, the changes seen on SVR are

affecting the changes on MAP because cardiac output did not reflect big changes. After analyzing the figures displaying MAP (fig.3) and SVR (fig. 12), we can deduct the relation and effect that SVR has on MAP values. About the time*condition interaction for MAP and the trend also for time*interaction effect it can be deducted that this effect was due to the different outcome caused by the condition low frequency-high amplitude which was the only condition to decrease SVR right after exercise and remaining as the lowest value at time point post 5 min as compared as the other conditions created at the same time a time*condition interaction on MAP where we can also see a different outcome on the same condition as compared to the other conditions and control.

Conclusion

The purposes of the study were to examine the acute effects of dynamic whole body vibration (WBV) training on small and large arterial stiffness, to examine the effects of different frequency and amplitude protocols in heart rate (HR), systolic and diastolic blood pressure, mean arterial pressure (MAP), cardiac output (CO), and stroke volume (SV) and identify the best WBV protocol to decrease acutely arterial stiffness. This study questions were as follows: Are there any changes in small and large arterial stiffness following a bout of whole body vibration workout with the different amplitude and frequency? Are there any changes in heart rate (RHR), systolic and diastolic blood pressure, mean arterial pressure (MAP), cardiac output (CO) and stroke volume (SV) following a bout of whole body vibration workout with the different amplitude and frequency? Which vibration settings would show the best results in decreasing arterial stiffness?

Research Hypothesis 1. There would be different changes in small and large arterial stiffness when using different amplitudes and frequencies.

We were not able to demonstrate that WBV protocols using different amplitudes and frequencies produce statistical difference on acute effects on arterial stiffness after a bout of 10 sets of 60 seconds of dynamic squats on the vibration platform; this could be in part due to the equipment used that performed the waveform analyses at the brachial artery which needed a larger systemic effect in order to show better results.

Research Hypothesis 2. Amplitude and frequency would create different changes in HR, SBP, DBP, MAP, CO and SV after a bout of WBV.

Systolic blood pressure and mean arterial pressure were the only variables in which a significant interaction between condition and time was observed. For the rest of the hemodynamic markers there were no significant differences found when using different frequencies and amplitudes.

Research Hypothesis 3. Lower frequency in combination with high amplitude would be the best protocol to decrease arterial stiffness.

At this point, it is not possible to accurately define the best protocol to decrease arterial stiffness when using WBV training. Low frequency in combination with high amplitude seems to have a positive effect on arterial stiffness and present some effects on vascular resistance and mean arterial pressure but no conclusive evidence was found.

This study is novel in that it is the first study to test the effects of different protocols varying on frequency and amplitude on arterial stiffness and hemodynamic responses. The problem presented in this study is that currently there was no specific protocol for WBV training to decrease arterial stiffness. Even when there is evidence of the effectiveness of this method to reduce arterial stiffness acutely and long term; the varying methodology being utilized in the

literature does not allow implementing the best protocol to get the best results and also it does not permit to get consistent results on every study.

There is a need for further research in this subject to better determine the best vibration protocols to be implemented in the clinical setting and to be able to get the best possible results when trying to decrease arterial stiffness using WBV training. Future studies should use equipment that can provide information on peripheral and central arterial elasticity in order to evaluate the localized changes produced by the exercise intervention. In addition, different study designs with more sets or shorter rest periods in order to increase the intensity and potentially increase the level of changes reflected on arterial stiffness and hemodynamics. There is an evident need for new and efficient training techniques as it is WBV to be implemented in health, commercial and home settings which will produce positive health improvements with less time and time restrictions due to the increasing incidences of cardiovascular disease.

Appendix I

ATTENTION

Participants Needed

MALES BETWEEN 18 AND 40 YEARS OLD

The Health and Human Performance Department would like to invite you to participate in a research study at the University of Texas at Brownsville to investigate the acute effect of whole body vibration exercises with various Acute Effects of Whole Body Vibration Exercises with Various Frequencies and Amplitudes on Arterial Stiffness in Males.

Participants will be required to attend for approximately 60-70 minutes each of the total of 5 days.

PLEASE CONTACT:

Omar Apodaca
(956) 525-5178
omar_apo@hotmail.com

OR

Dr. Murat Karabulut
(956) 882-7237
Murat.Karabulut@utb.edu

Appendix II

The University of Texas at Brownsville
Institutional Review Board
Informed Consent to Participate in a Research Study

Project Title: **Acute Effects of Whole Body Vibration Exercises with Various Frequencies and Amplitudes on Arterial Stiffness in Males**

Principal Investigator: Omar Apodaca and Dr. Murat Karabulut
Department: Health and Human Performance

You are being asked to volunteer for this research study. This study is being conducted at the Exercise Physiology laboratory in the Biomedical Research 2. You were selected as a possible participant because of your inquiry into the study.

Please read this form and ask any questions that you may have before agreeing to take part in this study.

Purpose of the Research Study

The purposes of the study are: 1) To examine the acute effects of dynamic whole body vibration (WBV) training on small and large arterial stiffness. 2) To examine the effects of different frequency and amplitude protocols in heart rate (HR), systolic and diastolic blood pressure, mean arterial pressure (MAP), cardiac output (CO), and stroke volume (SV). 3) Identify the best WBV protocol to decrease acutely arterial stiffness.

Number of Participants

15 male participants will take part in this study.

Procedures

If you agree to be in this study, you will be asked to do the following:

a. You will be required to visit the research labs in the Department of Health and Human Performance on 5 separate days for a total time commitment of about 5.5 hours.

b. On the first visit (about 90 minutes), you will be required to read and sign an informed consent, PAR-Q and health status questionnaire before any testing takes place. Participants that answer yes to any PAR-Q question, or have blood pressure higher than 140/90 mmHg will be excluded from this study. Finally a control session will take place with the exact same procedures as the exercise conditions but without the application of whole-body vibration.

You will then have have a introductory session where the exercise protocol and tests will be explained, exercise protocols will be randomly assigned and answered any possible question.

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Approval Date 5/12/2014
Expiration Date 4/23/2015

c. On the next 4 visits (**each visit separated by at least 48 hours**), each of about 60 minutes, participants will perform 10 sets of 60 seconds of dynamic squats on the vibration platform with 60 seconds rest between. Each session will have different vibration settings varying frequency and amplitude

Length of Participation

You will be required to visit the research labs in the Department of Health and Human Performance on five separate days for a total time commitment of approximately 5.5 hours.

This study has the following risks:

The study has the following risks:

You understand there are minimal risks to heathy individuals when performing any of the requirements for this project. However, even though these standard protocols have been approved at numerous other institutions and will be performed by qualified and trained personnel, You should be aware of the following:

Benefits of being in the study are

The benefits to participation are: You can receive information about your hemodynamic measures such as resting heart rate, blood pressure, , cardiac output, mean arterial pressure, stroke volume. resting BP and HR. Also, you will obtain information about your arterial elasticity health from Pulse Wave Analysis assessment.

Injury

In case of injury or illness resulting from this study, emergency medical services will be contacted. However, you or your insurance company may be expected to pay the usual charge from this treatment. The University of Texas at Brownsville has set no funds to compensate you in the event of injury.

Confidentiality

In published reports, there will be no information included that will make it possible to identify you without your permission. Research records will be stored securely and only approved researchers will have access to the records.

There are organizations that may inspect and/or copy your research records for quality assurance and data analysis. These organizations include Dr. Murat Karabulut and the UTB Institutional Review Board.

Costs

There is no cost for participation.

Compensation

You will not be reimbursed for you time and participation in this study.

Rights

Refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled. You can discontinue participation at any time without penalty or loss of benefits to which you are otherwise entitled.

Voluntary Nature of the Study

Participation in this study is voluntary. If you decline to participate, you will not be penalized or lose benefits or services unrelated to the study. If you decide to participate, you may decline to answer any question and may choose to withdraw at any time.

Waivers of Elements of Confidentiality

Your name will not be linked with your responses unless you specifically agree to be identified. Please select one of the following options

_____ I consent to being quoted directly.

_____ I do not consent to being quoted directly.

Contacts and Questions

If you have concerns or complaints about the research, the researcher(s) conducting this study can be contacted at the Department of Health and Human Performance: Omar Apodaca, B.S., (956)525-5178, omar.apodaca47@utb.edu OR Dr. Murat Karabulut, Ph.D., The University of Texas at Brownsville, (956)882-72367236, murat.karabulut@utb.edu. You are encouraged to contact the researcher if you have any questions. If you have any questions about the right of research subjects, contact the Chairman of the UTB IRB - Human Subjects or the Office of Research at UTB (956) 882-7731.

You are voluntarily making a decision whether or not to participate. Your signature indicates that, having read and understood the information provided above, you have decided to participate. You will be given a copy of this information to keep for your records. If you are not given a copy of this consent form, please request one.

Statement of Consent

I have read the above information. I have asked questions and have received satisfactory answers. I consent to participate in the study.

Signature Date

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Approval Date 5/12/2014
Expiration Date 4/23/2015

Appendix III

Data Collection Sheet

NAME:______________________________ DATE:______________

HEIGHT:________in. WEIGHT:__________lbs. AGE:_________

PHYSICIANS NAME:_____________________ PHONE:____________

PHYSICAL ACTIVITY READINESS QUESTIONNAIRE (PAR-Q)

	Questions	Yes	No
1	Has your doctor ever said that you have a heart condition and that you should only perform physical activity recommended by a doctor?		
2	Do you feel pain in your chest when you perform physical activity?		
3	In the past month, have you had chest pain when you were not performing any physical activity?		
4	Do you lose your balance because of dizziness or do you ever lose consciousness?		
5	Do you have a bone or joint problem that could be made worse by a change in your physical activity?		
6	Is your doctor currently prescribing any medication for your blood pressure or for a heart condition?		
7	Do you know of any other reason why you should not engage in physical activity?		

If you have answered "Yes" to one or more of the above questions, consult your physician before engaging in physical activity. Tell your physician which questions you answered "Yes" to. After a medical evaluation, seek advice from your physician on what type of activity is suitable for your current condition.

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