Utah State University
DigitalCommons@USU

Undergraduate Honors Theses | Honors Program

12-1-2010

A Comparison of Muscle Activity Responses of Adults and Children during Whole Body Vibration

Dustin Blair Nash
Utah State University

Recommended Citation
Nash, Dustin Blair, "A Comparison of Muscle Activity Responses of Adults and Children during Whole Body Vibration" (2010). *Undergraduate Honors Theses*. Paper 71.
http://digitalcommons.usu.edu/honors/71

This Thesis is brought to you for free and open access by the Honors Program at DigitalCommons@USU. It has been accepted for inclusion in Undergraduate Honors Theses by an authorized administrator of DigitalCommons@USU. For more information, please contact becky.thoms@usu.edu.

A Comparison of Muscle Activity Responses of Adults and Children during Whole Body Vibration

by

Dustin Blair Nash

Thesis submitted in partial fulfillment
of the requirements for the degree

of

DEPARTMENTAL HONORS

in

Human Movement Science
in the Department of Health, Physical Education, and Recreation

Approved:

Thesis/Project Advisor
Dr. Eadric Bressel

Departmental Honors Advisor
Dr. Eadric Bressel

Honors Program Director
Dr. Christie Fox

UTAH STATE UNIVERSITY
Logan, UT

Fall 2010

ABSTRACT

Results of recent studies have suggested that attenuation and transmissibility of WBV in adults and children are similar, but due to anatomical differences, it is hypothesized that children employ different strategies. One suggested strategy is that of muscle tuning, whereby muscle activity levels are adjusted to control potentially dangerous accelerations produced by vibration resonance. The purpose of the study was to compare muscle activity responses between children and adults exposed to whole body vibration. It was hypothesized that the muscle activity in children would be greater than that in adults due to muscle tuning strategies. Eleven adults and fourteen children were exposed to WBV at three different frequencies while the EMG at the VL, TA, BF and GC were recorded. The results of this study suggest that muscle activity levels of children are greater than that of adults who are exposed to standing WBV. This suggests that children may be utilizing muscle tuning in order to attenuate standing WBV. This is important to understand before the application of therapeutic WBV to children so as to avoid its application in cases where harm could occur.

DEDICATION

This thesis is dedicated to my mother, who has never let me doubt that learning and exploration are of utmost importance. Thank you for everything.

ACKNOWLEDGMENTS

I would like to acknowledge all of the support by the HPER Department and the USU Biomechanics lab, especially Dr. Eadric Bressel. He has patiently supported me in my research endeavors for several years and has been an excellent mentor. Without his assistance, the completion of this thesis would have been impossible.

TABLE OF CONTENTS

Abstract……..... 1

Dedication..... 2

Acknowledgements.....3

Table of Contents.....4

List of Abbreviations.....5

Introduction.....6

Methods.....7

Results.....11

Discussion.....12

Conclusion.....13

References.....14

Author's Biography.....16

LIST OF ABBREVIATIONS

WBV - Whole Body Vibration

EMG - Electromyography

MVC – Maximal Voluntary Contractions

VL – Vastus Lateralis

GC-Gastroconemius

TA-Tibialis Anterior

BF-Biceps Femoris

LIST OF TABLES AND FIGURES

Table 1-Demographic Data for Adult Participants……..……8

Table 2-Demographic Data for Children Participants……..……...……8

Figure 1. Position of Subject on Vibration Platform……...9

Figure 2. Results of EMG Comparison……..11

1. INTRODUCTION

Vibration, or oscillatory motion, can be artificially produced when a person stands upon vibration platforms. This vibration may produce health benefits which can be useful in training and therapy. Recent studies have reported that transmission and attenuation of vibration accelerations in children is very similar to that of adults. (Bressel and Smith, 2010) The amount of acceleration experienced at various landmarks on the body such as the sternum, tibia, and trochanters are similar when compared between children and adults. These findings are of significance due to the increasing use of whole body vibration as a therapeutic intervention for children with debilitating conditions such as autism or cerebral palsy (Semleret al., 2007, 2008; Ward et al., 2004). Moreover, the previous research has reported that the transmitted vibration from a vibrating platform to the head is approximately 85% lower (Mansfield and Griffin 1998). This finding is of clinical relevance since large accelerations experienced by the head and brain can have deleterious and long lasting effects (Griffin 1996).

The mechanism of vibration reduction in adults has been examined in previous research, with various attributing factors including muscle activity level, joint angles, and skeleton structure. For example, it has been observed that knee joint angles less than 30 degrees transmit more vibration to the head. At present, the mechanisms which allow for similar attenuations in children are not well understood. Still, the attenuation is important so that the body can control for vibration resonance. When resonance occurs, the energy of the oscillations will reinforce one another, creating levels of acceleration and forces which can be dangerous. The body then relies on various factors, including those listed above, to dampen and control the production of these resonance effects.

It is hypothesized that muscle activity plays a major role in the measurable reduction of vibration motion. Electromyography (EMG) of several different muscle groups might give insight into ways that muscle activity may differ among children and adults when they are exposed to vibration motion. Electromyography detects the electrical stimulation that is associated with muscle excitement. As muscles are excited, their stiffness and elasticity change, which changes the transmission of energy. By monitoring the changes in muscle EMG in the different age groups, we can learn more about the degree to which muscle attenuation is affected by vibration motion (Wakeling and Nigg 2001).

The purpose of this study is to provide just such a comparison under controlled conditions to provide insight to the validity of the Muscle Tuning Theory in the attenuation of vibration by children. This will provide understanding and safety recommendations for further research and therapeutic uses of WBV with children.

2. METHODS

2.1 Research Design

The study used a quasi-experimental between group research design to address the purpose of the study. The independent variable was the sample (adults or children), while the dependent variable was activity of lower limb muscles as measured by electromyography (EMG).

2.2 Participants

Twenty-five subjects, eleven adults (5 male and 6 female) and fourteen children (7 male and 7 female), were asked to participate in the study. The participants were a sample of convenience and were included in the study if they were free of nueromusculoskeletal disorders. Before taking part in the study, participants or their legal guardians read and signed an informed consent

form approved by the institution's institutional review board. The physical characteristics of the participants are displayed in Tables 1 and 2.

Adult Participants			
Characteristic	**Mean**	**SD**	**Min-Max**
Age (yrs)	24.5	5.87	21-41
Height (cm)	175	10.3	162-190
Mass (kg)	77.2	24.1	50.8-95.3

Table 1-Demographic data for Adult Participants

Children Participants			
Characteristic	**Mean**	**SD**	**Min-Max**
Age (yrs)	8.93	2.69	5-12
Height (cm)	138.53	19.1	
Mass (kg)	33.38	12.33	20.4-58.1

Table2-Demographic data for Children Participants

2.3 WBV

Whole Body vibration was performed at 28, 33, and 42 hz on a commercially available vibration platform (i.Tonic International B.V., Huizen, Netherlands). Validity of the vibration platform was assessed during pilot testing to ensure that there was no interference. Multiple frequencies were used to ensure that no anomalous results which only occurred in a narrow frequency range were interpreted incorrectly. These frequencies were chosen as they represent a

range common to most commercial vibration platforms. The order of frequencies was randomized. Participants were asked to find a comfortable position with flexed knees as is shown in figure 1. Participants stood barefoot on the platform and were asked to look straight ahead during the WBV.

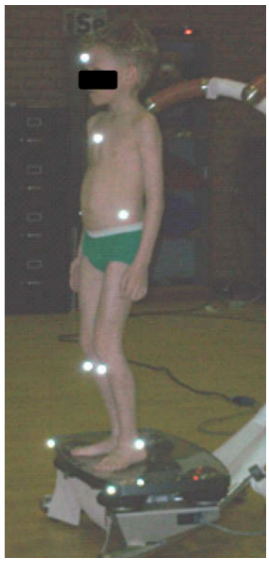

Fig. 1 shows knee angle and position of subjects on vibration platform.

2.4 EMG

Recordings of EMGsignals were performed using a Muscle Lab EMG system (Boscosystem, Rieti, Italy) system with the use of bipolar electrodes. Skin was prepared by the removal of hair and cleaning with alcohol wipes to ensure a good signal. The electrodes were placed in the center of the muscle belly which was located by a voluntary contraction against manual resistance. The leads of the electrode were aligned with the muscle length. Signals were recorded from the vastus lateralis (VL), biceps femoris (BF), anterior tibialis (AT), and gastroconemius lateralis (GL).

Before the recording, the EMG signals were normalized to an isometric voluntary contraction (MVC) of each muscle before WBV. The MVCs for the VL and the TA were performed

sitting in a chair. Manual resistance was applied as the patient was first asked to extend his/her knee, and then was asked to lift his/her toes towards their shin. The BF and GC MVC's were performed in a standing position while supported on a chair. Manual resistance was applied as the patient was asked to flex his/her knee and then to raise upon his/her toes. Each MVC was performed twice; the first being used for familiarization and the second for normalization, each for approximately 5 seconds while verbal encouragement was supplied. After participants completed MVC testing the EMG, data was then recorded for 10 seconds while the participant was exposed to the frequencies listed above in a random order.

2.5 Statistical Analysis

Although10 seconds were recorded during the vibration exposure at each frequency, only seconds 1-9 at each frequency were analyzed to reduce variability involved in the startup of the vibration platform. These EMG signals which were recorded were normalized to the MVC values previously recorded. These results were then reported in values of %MVC. The time periods examined were reviewed and any value which exceeded 150% of the MVC was discarded as an outlier. The remaining values were then statistically analyzed using independent T-tests.

3. RESULTS

3.1 Relative Muscle Activity

The results of the statistical analysis are shown below in Fig 2.

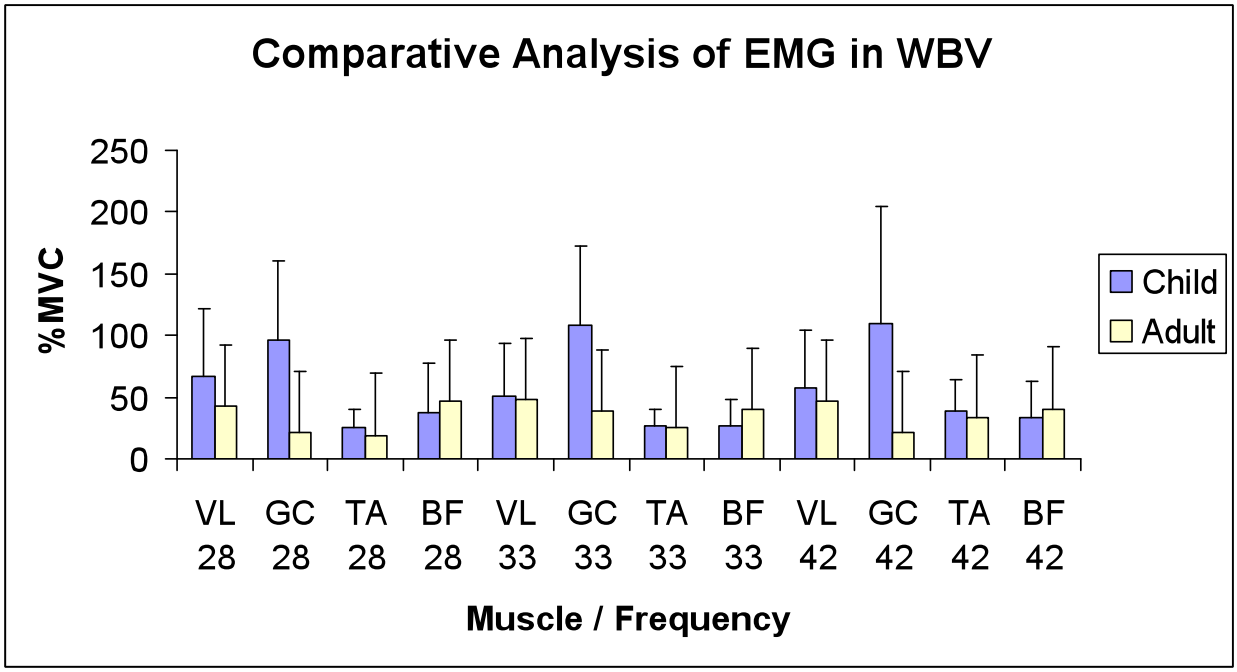

Fig 2. Compares the values of each group of subjects for each muscle and at each of the frequencies that was tested.

In all cases, the muscle activity in children was greater than that in adults. The most significant differences occurred in the GC muscles (p=.060-.097) and VL muscles (p=.024-.092). Depending on the frequency and muscles which were compared, the differences ranged in magnitude from 2%-88%. The differences in the muscle activity were similar in each muscle at each of the different frequencies.

4. DISCUSSION

The purpose of this study was to evaluate if significant differences existed between the muscle activity of children and adults when they were exposed to whole body vibration. Recent studies suggested similarities in the transmissibility of whole body vibration in adults and children (Bressel and Smith 2010). This is cause to consider the question of the method of attenuation utilized by each group. Many anatomical differences exist between the two groups identified in these studies and those examined in this study. The stiffness and composition of the skeletal system, body mass, and body composition are examples of these differences which could play potential roles in the mechanisms of attenuation. For example, children's bones have a higher percentage of collagen and will strain more before failure (Ding et al., 1997), which could also have some effect on the transmissibility of the vibration.

Muscle activity was chosen as the focus of this study as it has been identified as a likely mechanism in previous research. Wakeling and his coworkers described a muscle tuning theory to explain the attenuation of vibration of soft tissues from the impact forces of walking, running, and WBV in adult subjects. They suggested that increases in muscle activity might be used to dampen the vibration experienced by a subject. As the number of attached cross bridges in a muscle increase during activation, the structure changes and the damping coefficient increases. In addition, the increase in tension in the muscle elevates the resonant frequency of the soft tissue above that which the body is experiencing, effectively "tuning" the muscle to minimize the effects of the WBV. (Wakeling and Nigg, 2002). It was then hypothesized that children might employ the same mechanism to control vibration resonance, which can cause injury, occurring during WBV.

EMG was used to measure the muscle activity during WBV, as an increased level of muscle activity in children could be indicative of the activation of the muscles for muscle tuning purposes. Indeed a greater level of elevated muscle activity was experienced by the children's group. This could provide support to the suggestion by Bressel and associates that muscle tuning might be the preferred strategy for the attenuation of vibration by children.

This study is of clinical significance as it applies to therapeutic whole body vibration with children who would have detrimental effects to a stimulated activation of their muscles. For instance, it would be advisable for children who have recent injuries to soft tissues that may be involved in standing WBV (e.g., ankle sprains or muscle strains in the legs) to allow full healing before being exposed to WBV, as it could exacerbate the problem. Also, children with excessively tight muscles, as occurs in disorders such as Cerebral Palsy, could benefit from stretching prior to exposure to WBV. This would serve to prevent injury from the activation of muscles which are already taut.

5. CONCLUSION

This comparative study would suggest that due to the evidence of elevated muscle activity during WBV, children may indeed be employing a muscle tuning strategy to attenuate WBV. Future research could further address which muscles are specifically involved and differences in subsets of the groups, such as male and female.

REFERENCES

Bressel, E., Smith, G., & Branscomb, J. (2010). Transmission of whole body vibration in children while standing. *Clinical Biomechanics, 25*(2), 181-186.

Cormie, P., Deane, R. S., Triplett, T., & McBride, J. M. (2006). Acute Effects of Whole Body Vibrations on Muscle Activity, Strength, and Power. *Journal of Strength & Conditioning Research (Allen Press Publishing Services Inc.), 20*(2), 257-261.

Ding, M., Dalstra, M., Danielsen, C.C., Kabel, J., Hvid, I., Linde, F., (1997). Age variations in the properties of human tibial trabecular bone. *Journal of Bone and Joint Surgery,* 79, 995–1002.

Dolny, D.G., Reyes, G.F., (2008). Whole body vibration exercise: training and benefits. *Current Sports Medicine Report*, 7, 152–157.

Griffin, M.J., (1996). *Handbook of Human Vibration.* Academic Press, London.

Hazell, T. J., Jakobi, J. M., & Kenno, K. A. (2007). The effects of whole-body vibration on upper- and lower-body EMG during static and dynamic contractions. *Applied Physiology, Nutrition & Metabolism,* 32(6), 1156-1163.

Jordan, M. J., Norris, S. R., Smith, D. J., & Herzog, W. (2005). Vibration Training: An Overview of the Area, Training Consequences, and Future Considerations. *Journal of Strength & Conditioning Research,* 19(2), 459-466.

Kiiski, J., Heinonen, A., Järvinen, T. L., Kannus, P., & Sievänen, H. (2008). Transmission of Vertical Whole Body Vibration to the Human Body. *Journal of Bone & Mineral Research,* 3(*2*8), 1318-1325.

Mansfield, N.J., Griffin, M.J., 1998. Effect of magnitude of vertical whole-body vibration on absorbed power for the seated human body. *Journal of Sound Vibration,* 215, 813–825.

Pollock, R.D., Woledge, R.C., 2010. Muscle activity and acceleration during whole body vibration: Effect of frequency and amplitude. *Clinical Biomechanics,* 25, 840-846

Semler, O., Fricke, O., Vezyroglou, K., Stark, C., Schoenau, E., 2007. Preliminary results on the mobility after whole body vibration in immobilized children and adolescents. *Journal of Musculoskeletal Neuronal Interactions,* 7, 77–81.

Semler, O., Fricke, O., Vezyroglou, K., Stark, C., Stabrey, A., Schoenau, E., 2008. Results of a prospective pilot trial on mobility after whole body vibration in children and adolescents with osteogenesis imperfecta. *Clinical Rehabilitation,* 22, 387–394.

Wakeling, J.M., Nigg, B.M., 2001. Modification of soft tissue vibrations in the leg by muscular activity. *Journal of Applied Physiology,* 90, 412–420.

Wakeling, J.M., Nigg, B.M., Rozitis, A.I., 2002. Muscle Activity damps the soft tissue resonance that occurs in response to pulsed and continuous vibrations. *Journal of Applied Physi-olgy,* 93, 1093-1103

Ward, K., Alsop, C., Caulton, J., Rubin, C., Adams, J., Mughal, Z., 2004. Low magnitude mechanical loading is osteogenic in children with disabling conditions. *Journal of Bone and Mineral Research,* 19, 360–369.

AUTHOR'S BIOGRAPHY

Dustin Nash, of Weston, Idaho, graduated in 2004 from West Side High School. He entered Utah State University with a National Level II scholarship and a research fellowship. After experimenting with several majors, he pursued a degree in Human Movement Science with a minor in Chemistry. He has served as a research assistant for 3 years in the Biomechanics laboratory. He also served as director for the USU Habitat for Humanity Chapter and as Recruitment Chair for the Val R. Christensen Service Center. After he graduates in December of 2010, Dustin intends to pursue a career in medicine and public health.