Elucidating the Effects of Two and Ten Minutes of Lower Body Positive Pressure on Blood Pressure and Heart Rate in College Age Adults 18-30 Years Old

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Abstract

The purpose of this study was to investigate the effects of two and ten minutes of lower body positive pressure (LBPP) at a percent unloading of 75%, 50%, and 25% body weight on resting systolic/diastolic blood pressure (SBP/DBP) and heart rate (HR) in a standing position. One group was exposed to two minutes of LBPP (6 males and 4 females) while group two was exposed to ten minutes of LBPP (3 males and 7 females). Resting HR, SBP and DBP measurements were recorded every two and ten minutes. A repeated measures multivariate analysis of variance (MANOVA) was performed across conditions to analyze data at the p<.05 significance level. Data suggest that LBPP did significantly alter barometric pressure, while systolic/diastolic blood pressure and heart rate were found not to be significant across conditions. Treadmills that utilize LBPP are safe to used and do not significantly affect SBP, DBP and HR.

Keywords: Lower body positive pressure, heart rate, blood pressure

1. Introduction

The technology has been developed that utilizes lower body positive pressure (LBPP) to alter the weight of an individual while jogging (Gleim and Nicholas 1989, Eastlack Hargens, Groppo, Steinbach, White, and Pedowitz, 2005). While hydrotherapy, harness systems, and specialized mechanics have shown to reduce forces during weight bearing exercises, LBPP treadmills produce a significant unweighting of the subject with minimal alteration of gait kinematics(Figueroa, Manning, and Escamilla, 2011).

1.1 Literature Review

Even among young adults, injuries and/or obesity can become debilitating factors. Exercises at times can be counterproductive. Due to high knee forces (between two and three times body weight), non-weight bearing, or partial weight bearing is often recommended, which often delays return to full function (Figueroa, Manning, and Escamilla, 2011). This reduced the risk of stress-related injuries, while allowing individuals to train smarter and faster in a controlled environment (AlterG, 2012).

Lower body positive pressure has been utilized to help explain the many acute physiologic responses such as resting systolic, diastolic and heart rate in adults and the mechanisms directly or indirectly involved in their adaptations (Takacs, Leiter, and Peeler, 2011, Fisher et. al., 2009, Ru Q et. al., 2009, Gallagher et. al., 2006, Hofsten A, Elmfeldt D, Svärdsudd K., 1999).

Onlyone other research investigation that has explored the effects of lower body positive pressure (LBPP) on heart rate, systolic and diastolic measurements in a standing resting position (Cutuk et.al., 2006). They investigatedthe safety of LBPP on systolic, diastolic, heart rate and exercise while utilizing LBPP. The second part of their investigation looked at the effects of LBPP on walking and running gaits. Our investigation therefore sought to help quantify the effects of LBPP at 100%, 75%, 50% and 25% unloading in resting systolic, diastolic and heart rate with two minutes and ten minute exposure to LBPP.

2. Methodology

2.1 Participants and Data Collection

Data was collected on 20 adults between the ages 18-30 years old (9 males and 11 females).Two sets of data were collected, one for the two minute (6 males and 4 females) exposure to LBPP and one for the ten minute (3 males and 7 females) exposure to LBPP. This was applied in a graded manner such that when one data collection was completed for each percent unloading, more LBPP was added for the next data collection period. Group one total exposure to LBPP at all percent unloading (100%, 75%, 50%, and 25%) was six minutes. Group two total exposure time to LBPP at all percent unloading (100%, 75%, 50%, and 25%) was thirty minutes. Unloading at 100% served as a base control because there was no actual unloading of body weight. Subject selection was determined after the completion of a health check questionnaire for any pre-existing medical conditions that may exclude them from participating in the study. Such conditions included cardiac dysfunctions and/or heart attacks, and/or unmanaged or treated high blood pressure. Subjects were required to rest for five minutes prior to any base line blood pressure readings. Only subjects who displayed a resting systolic/diastolic blood pressure of less than 139mmHg/88mmHg qualified for the study. Prior to testing, all subjects signed an Informed Consent Form approved through the University of Texas-Pan American Institutional Review Board for Human Subjects Testing.Prior to being placed in a LBPP environment, all subjects were required to wear a pair of neoprene shorts, necessary to maintain pressure in the LBPP chamber as recommended by the manufacturer.

In the first part of the study, subjects were asked to stand quietly for two minutes prior to any blood pressure and heart rate measurements. Measurements were taken after two minutes across conditions (100%, 75%, 50%, 25%) respectively. The second data collection required all subjects to stand quietly for ten minutes prior to data collection. Resting blood pressure and heart rate in the standing position were recorded at different percentages of their body weight using the OMRON HEM-790IT automatic blood pressure monitor to eliminate possible measurement error by the investigators. All subjects were measured on the left arm for consistency. A barometer (Thomas Scientific Hygrometer Thermometer Barometer DP) was placed securely inside the treadmill deck to quantify the barometric pressure changes across all conditions (100%, 75%, 50%, and 25%).

3. Results

A one-way analysis of variance across conditions was used to analyze the data at the p<.05 level of significance.Mean barometric pressure during two minutes of LBPP increased significantly from 758.79 mmHg at 100% body weight (BW) to 769.77 mmHg, 781.85 mmHg, and 793.94 mmHg at 75% BW, 50% BW, and 25% BW, respectively, *(p<.001).* Mean systolic blood pressure varied from 112.8 mmHg at 100% BW to 113.40 mmHg, 115.6 mmHg, and 115.7 mmHg at 75% BW, 50% BW, and 25% BW, respectively. Mean diastolic blood pressure varied from 74.6 mmHg at 100% BW to 72.7 mmHg, 74.6 mmHg, 73.3 mmHg at 75% BW, 50% BW, and 25% BW, respectively. Systolic and diastolic blood pressures were found not to be significant across conditions *(p=.847),(p=.790).* Mean heart rate varied from 78.8 bpm at 100% BW to 76.5 bpm, 73.3 bpm and 71.8 bpm at 75% BW, 50% BW, and 25% BW, respectively. Heart rate was found not to be significant through MANOVA analyses, *(p<.388).*

Mean barometric pressure during ten minutes of LBPP increased significantly from 755.85 mmHg at 100% body weight (BW) to 766.8 mmHg, 778.88 mmHg, and 790.92 mmHg at 75% BW, 50% BW, and 25% BW, respectively, *(p<.001).* Mean systolic blood pressure varied from 112.8 mmHg at 100% BW to 111.6 mmHg, 114.7 mmHg, and 114.3 mmHg at 75% BW, 50% BW, and 25% BW, respectively. Mean diastolic blood pressure varied from 76.3 mmHg at 100% BW to 74.8 mmHg, 75.8 mmHg, 75.7 mmHg at 75% BW, 50% BW, and 25% BW, respectively. Systolic and diastolic blood pressures were found not to be significant across conditions *(p=.619),(p=.642).* Mean heart rate varied from 81.6 bpm at 100% BW to 76.3 bpm, 74.1 bpm and 72.3 bpm at 75% BW, 50% BW, and 25% BW, respectively. Heart rate was found not to be significant through MANOVA analyses, *(p<.161).*

4. Discussion

Findings in this study suggest that exposure at either two or ten minutes of lower body positive pressure (LBPP) did not significantly affect resting systolic and diastolic measurements while standing across conditions of unloading at 100%, 75%, 50%, and 25%. There was no LBPP at 100%; thus, this served as a control for comparison with the rest of the measurements. Figures 1.0 and 2.0 illustrate graphically the systolic and diastolic patterns across LBPP unloading. Our results with systolic and diastolic blood pressure followed a similar pattern to those seen in Cutuk et al., 2006.Heart rate measurement data in our study was found not significant across the various percent unloading with either two or ten minute exposure to LBPP. The only variable in our study found to be significant was barometric pressure across conditions. Although Figure 3.0 and Figure 4.0 illustrate a general trend downward towards the highest chamber pressure in our study, heart rate was found not significant across conditions. Cutuket.al., 2006 found significance in heart rate in LBPP levels greater than 20 mmHg. Their investigation applied LBPP in a graded manner from 10, 20, 30, 40, and 50 mmHg with an adjustment period of one minute prior to any data collection (Cutuk et. al., 2006). Our study also applied LBPP in a graded manner; however our method of pressure evaluation was based on recordings from a hand held barometer that was placed within the LBPP chamber throughout the entire conditions for each subject. The main difference between our study and Cutuk et al., 2006 was in how percent unloading was quantified. Others have reported differences in cardiovascular parameters measured between some studies looking at the effects of LBPP on cardiovascular responses (Evans, 2013, Figueroa, 2011, Shi, 1993, Cutuk, 2006).Central venous pooling and mean arterial pressure (MAP) are hypothesized to be elevated with the application of LBPP in a supine and seated subjects (Cutuk et al., 2006).We hypothesize the same mechanism(s) are also in effect during the standing position in our study. Pooling of fluid in the abdomen has also been observed in another study with the application of LBPP in a standing resting position(Evans, 2013).Our investigation did not measure such pooling of the blood within the abdominal region.There is indication that such results suggest increase in peripheral vasomotionwhich were inhibited by LBPP(Evans, 2013). Furthermore, this suggest that the elevation of blood pressure may be due to increases in total peripheral resistances through the application of LBPP which maybe sensed and acted by a component of arterial baroreflex(Evans, 2013, Kaufman 2010, Matsukawa et.al., 2013, Monahan, 2007, Secher and Amann 2012, Shi, Crandall and Raven, 1993, and Williamson 2010).Suppression of sympathetic drive to adjust heart rate appears to provide evidence that there is a cardiopulmonary and/or mechano/metabo reflex inhibition of arterial baroreflexes(Evans, 2013).

There are differences in the few studies that have looked at the effects of LBPP on cardiovascular parameters such as blood pressure and heart rate. Some studies have looked at standing and supine positions during the application of LBPPLBPP (Cutuk A, 2006, Evans, 2013, Figueroa MA, 2011, Hoffman, Martin D., 2011, Hofsten A, 1999, Nishiyasu T, 1998, Nishiyasu T, 2007).One investigation suggests that the size of the seal at the waist enclosing the subject to the chamber compartment is critical in measuring the effects of LBPP on vascular resistance and blood pressure(Evans, 2013). This study however, did not measure the size of the seal at the waist(Evans, 2013).Our study did not record the size of the seal at the waist as neither did Cutuk, et al., 2006; therefore, we had no way of quantifying whether the size of the seal at the waist enclosing the subject to the chamber compartment affects vascular resistance and blood pressure.

5. *Implications*

Results from this investigation and others suggest that LBPP treadmills are a beneficial form of rehabilitation. This would allow patients to perform their therapy comfortably and safely in a partial-weight bearing environment. Furthermore, recent studies investigating standing resting blood pressure and heart rate as a result of the application of LBPP for the unloading of patients have found it not to raise blood pressure significantly. Since no studies to date have used clinical populations with hypertension, attention should be placed on BP and HR on patients with possible vascular disorders.

6. Limitations and Further Research

A limitation of this study is that our participants were college-age students between the ages of 18-30 years old. There is a need to replicate this investigation in a clinical population such as in a physical therapy setting. Measuring or estimating stroke volume would have added some value in order to determine if it moves in the same direction as heart rate did in this study.This type of research should be investigated further to help establish clinical standards.

7. Conclusion

It is recommended that manual and/or automated blood pressure be recorded initially prior to any LBPP implementation.It is further recommended that patients with a history of hypertension should be given a sitting and standing resting blood pressure check prior to any ambulation on a LBPP treadmill. Lastly, in these individuals a manual and/or automated blood pressure recording should be checked periodically at the onset of exercise during LBPP.

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References

About the AlterG.(2012). AlterGwebsite.http://www.alterg.com/. Accessed May 2, 2012.

Cutuk A, Groppo ER, Quigley EJ, White KW, Pedowitz RA, Hargens AR. (2006). Ambulation in simulated fractional gravity using lower body positive pressure: Cardiovascular safety and gait analysis. Journal of Applied Physiology, 101:771-777.

Eastlack R, Hargens AR, Groppo ER, Steinbach GC, White KK, Pedowitz RA. Lower body positive-pressure exercise after knee surgery.(2005).Clinical Orthopedic and Related Research, 431:213-219.

Evans JM, Mohney L, Wang S, Moore Rk, Elayi S-C, Stenger MB, Moore FB, Knapp CF. (2013). Cardiovascular regulation during body unweighting by lower body positive pressure.Aviation, Space, and Environmental Medicine, Volume 84, No.11, November.

Figueroa MA, Manning J, Escamilla P. (2011). Physiological responses to the AlterG Anti-Gravity Treadmill.International Journal of Applied Science and Technology, 1:92-97.

Fisher J, Kim A, Young C, Ogoh S, Raven P, Secher N, and Fadel P, (2009). Influence of ageing on carotid baroreflex peak response latency in humans. Journal of Physiology, 587:5427-5439.

Fu Q, Shibata S, Hastings JL, Prasad A, Palmer MD, Levine BD. (2009).Evidence for unloading arterial baroreceptors during low levels of lower body negative pressure in humans. American Journal of Physiological Heart Circulation Physiology, 296:H480-8.

Gallagher K, Fadel P, Raven P, Smith S, Stromstad M, Ide K, and Secher N.(2006). The interaction of central command and the exercise pressor reflex in mediating baroreflex resetting during exercise in humans. Experimental Physiology, 91(1):79-87.

Gleim GW, Nicholas JA. (1989). Metabolic costs and heart rate responses to treadmill walking in water at different depths and temperatures. American Journal of Sports Medicine,17:248-252.

Hoffman, Martin D., and Haylee E. Donaghe. (2011). "Physiological responses to body weight–supported treadmill exercise in healthy adults." Archives of Physical Medicine and Rehabilitation 92.6, 960-966.

Hofsten A, Elmfeldt D, Svärdsudd K. (1999). Age-related differences in blood pressure and heart rate responses to changes in body position: Results from a study with serial measurements in the supine and standing positions in 30-, 50- and 60-year-old men. Blood Pressure, 8(4), 220-226.

Kaufman M. Metaboreflex control of the heart.(2010). Journal of Physiology, 588.7:1037-1038.

Mandal AK, Miller WG, Saklayen MG, Markert RJ.(1997). Comparison of manual versus automated blood pressure measurements in treated hypertensive patients.American Journal of Medical Sciences, 314:185-189.

Matsukawa K, Ishii K, Idesako M, Ishida T, Endo K, Liang N. (2013). Central command differentially affects aortic and carotid sinus baroreflexes at the onset of spontaneous motor activity. Autonomic Neuroscience: Basic & Clinical, 179(1-2):75-83.

Monahan, K. Effect of aging on baroreflexfunction in humans. (2007). American Journal of Physiology Regulatory Integrative and Comparative Physiology, 293:R3-R12.

Nishiyasu T, Nagashima K, Nadel ER, Mack GW. (1998). Effects of posture on cardiovascular responses to lower body positive pressure at rest and during dynamic exercise.Journal of Applied Physiology, 85:160-167.

Nishiyasu T, Nagashima K, Nadel ER, Mack GW. (2007). Effects of posture on peripheral vascular responses to lower body positive pressure.American Journal of Physiology Heart and Circulatory Physiology, 293:H670-6

Secher N, Amann M. (2012). Human investigations into the exercise pressor reflex.Experimental Physiology, 97(1):59-69.
Shi X, Crandall CG, Raven PB. (1993). Hemodynamic responses to graded lower body positive pressure.American Journal of Physiology Heart and Circulatory Physiology, 265:H69-H73.
Shi X, Potts JT, Foresman BH, Raven PB. (1993). Carotid baroreflex responsiveness to lower body positive pressure induced increases in central venous pressure. American Journal of Physiology, 265-H918-22.
Takacs J, Leiter JR, Peeler JD. (2011). Novel application of lower body positive pressure in the rehabilitation of an individual with multiple lower extremity fractures. Journal of Rehabilitation Medicine, 43:653-656.
Williamson J. (2010). The relevance of central command for the neural cardiovascular control of exercise.Experimental Physiology, 95(11):1043-1048.
Willms, J. (2009). My Heart Knows When to Beat Faster: How the Human Body Anticipates its own Needs During Exercise. Lethbridge Undergraduate Research Journal, 4(1):1-6.

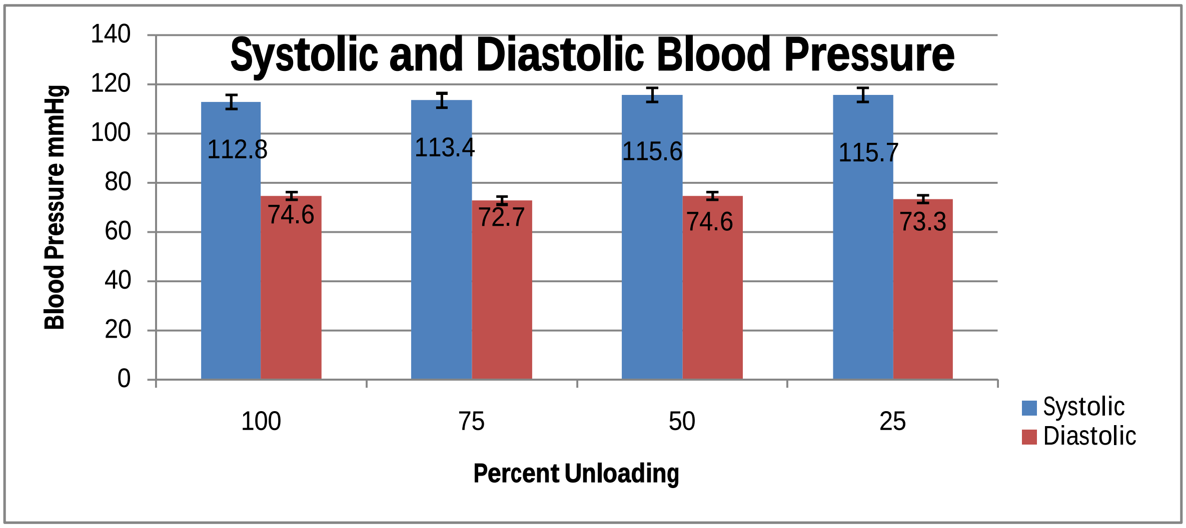

Figure 1.0: Effects of Two Minute Exposure to LBPP on Systolic, and Diastolic Blood Pressure (p=.847 and P=.790)

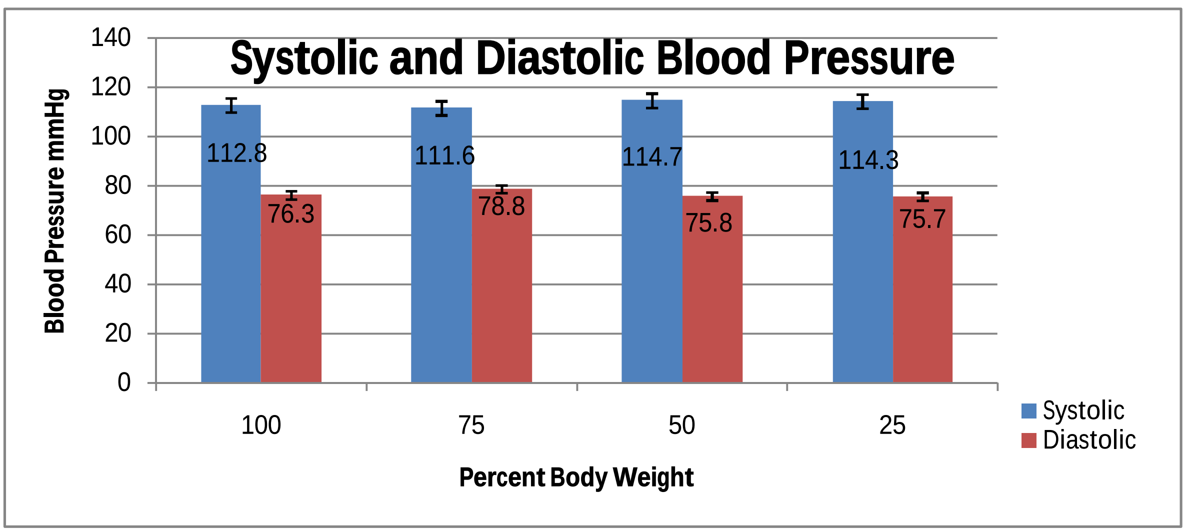

Figure 2.0: Effects of Ten Minute Exposure to LBPP on Systolic and Diastolic Blood Pressure (p=.619 and P=.642)

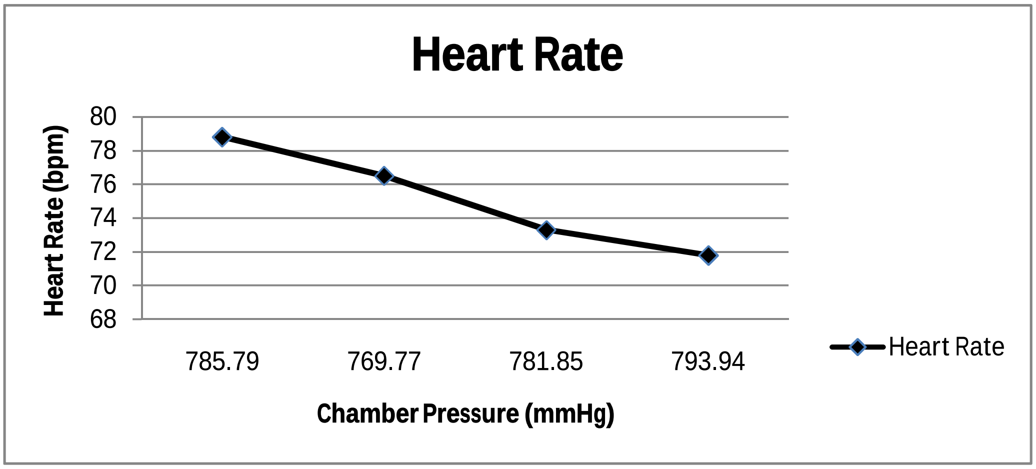

Figure 3.0: The Effects of Two Minute Exposure to Specific LBPP on Heart Rate (p=.388)

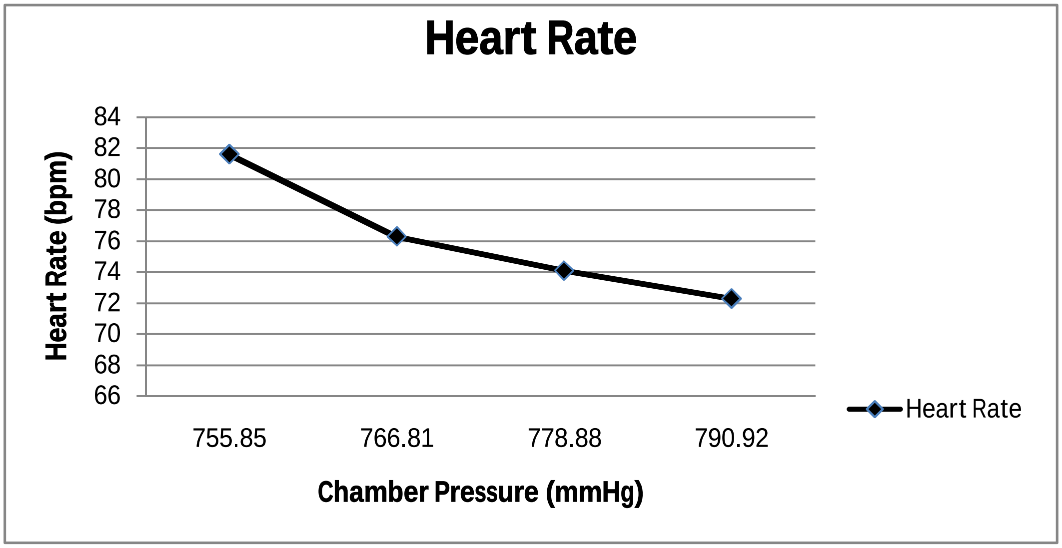

Figure 4.0: The Effects of Ten Minute Exposure to Specific LBPP on Heart Rate (p=.161)