Energy Expenditure of Obese Men Walking with Body Weight Support

Toni T. LaSala

Jordan Cola

Michael A. Figueroa

Department of Kinesiology
William Paterson University
300 Pompton Rd. Wayne, NJ 07470

Genevieve Pinto Zipp
School of Health and Medical Sciences
Seton Hall University
400 South Orange Ave, South Orange, NJ 07079

Abstract

Purpose: *To investigate the effects of energy expenditure during walking at 100% to 75% while on a lower body positive pressure treadmill (LBPP) on energy expenditure in men classified as obese.* ***Results:*** *Total EE, EEFM, and EEFFM were significantly lower (p<.05) at 75% BW compared to 100% BW.* ***Conclusion:*** *Un weighting on the LBPP can is safe and can be used as an effective exercise modality to increase energy expenditure over time.*

Keywords: lower body positive pressure treadmill, energy expenditure, fat mass, fat-free mass, obese.

1.Introduction

As food production continues to expand the variety of foods that are available and the increasing use of technology, Americans are consuming more calories than they are expending, resulting in an increase in obesity (WHO, 2015). Data from the Behavioral Risk Factor Surveillance System (BRFSS) of the Centers for Disease Control and Prevention (CDC) on measured heights and weights (BMI) of young adults indicates that the prevalence of obesity has significantly increased throughout the U.S. over the last 20 years. During 2011–2014, the prevalence of obesity in American adults was 36.5%. Projections support that 42% of Americans may end up obese by 2030 (up from 36% in 2010), with 11% being severely obese, roughly 100 or more pounds over a healthy weight (vs. 6% in 2010) (CDC, 2016). Obesity does not discriminate and is threatening the health of people of all ages, ethnicities and socioeconomic backgrounds across the United States. Understanding the mechanisms underlying how to regulate body weight is important for exercise prescription and consequently health outcomes. Energy expenditure (EE) during exercise and recovery are both important for weight control (Thompson, Townsend, Boughey, Patterson, & Bassett, 1998) and have important implications for targeted exercise programs. The American College of Sports Medicine (ACSM, 2014) recommends that most adults engage in moderate intensity cardiovascular exercise ata minimum of 150 minutes per week with an energy expenditure of approximately 1000 kilocalories per week (kcal/wk) and for weight loss 150 to 250 minutes per week or 300 to 500 kilocalories per day. Evidence-based clinical guidelines on obesity management support that physical activity is an important tool for improving insulin sensitivity, lipid profile and blood pressure given that it supports the reduction of body weight, body fat, and waist circumference, and can improve maximal aerobic capacity (VO_{2max}) (ACSM, 2014; NHLBI, 1998; NIH, 1998; WHO, 2010 & Wing, 1999).

Several studies have examined energy expenditure (EE) in overweight and obese subjects. Browning, Baker, Herron, and Kram(2005) looked at the metabolic cost of walking in obese men and women compared to normal weight men and women. The results of their study indicated that obese women had a 10% greater net metabolic rate (the cost of walking per kg of body weight) than obese men and normal weight women and a 20% greater net metabolic rate compared to normal weight men.

When looking at the effects of obesity and external loading on the net metabolic rate of walking, Griffin, Roberts & Kram (2003) found that net metabolic rate increased by 47% in normal weight men. As a result net metabolic rate increased by ~15% when normalized by total mass (body + load). Furthermore, obese subjects were carrying ~ 30% of their normal mass as extra adipose tissue (when accounted for differences in lean body mass) and their net metabolic rate increased by 10%. Griffin et al., 2003 concluded the energetic cost of walking is determined by body mass and that external loading and adipose tissue have similar effects. Obese individuals expend much more metabolic energy during walking than normal-weight individuals (Bloom & Marshall, 1967;Foster,**Wadden, Kendrick, Letizia, Lander, & Conill,** 1995; Melanson et al., 2003). However, the energy expended across walking speeds has only recently been established for obese female adults (Browning and Kram, 2005; Mattsson, Larsson & Rossner, 1997; Melanson, et al., 2003), and it is not well understood for obese men.These studies support that body mass significantly impacts resting metabolic rate and EE during a given activity and intensity impacts EE. Because obese individuals expend more energy than normal weight individuals (Browning &Kram, 2005), this may put them at a greater percentage of their maximum aerobic capacity, which may affect the duration of their exercise session (Alkurdi et al., 2010). As a result the relative effort required for overweight and obese individuals exert energy, may influence their participation in a walking program.

To determine the most appropriate type of exercise for the obese Lafortuna et al. (2008) compared energy expenditure (EE) and cardiovascular responses of walking on a treadmill (TM) and a cycle ergo meter. They found energy requirements of treadmill (TM) walking was higher than cycling and that the TM is more convenient for the obese population. However, overweight and obese individuals are at an increased risk of orthopedic injury due to excess body weight and may exacerbate existing joint conditions during weight bearing exercise (Felson et al., 1988). An optimal exercise environment for overweight and obese individuals is the water. The buoyancy effect of water reduces GRFs which is a major benefit for overweight and obese individuals to reduce stress on their joints (Alkurdi, Paul, Sadowski, & Dolny, 2010; Gleim & Nicholas, 1989; Greene et al., 2009; Pohl & McNaughton, 2003; Silvers, Rutledge, &Dolny, 2007). However, further investigations have shown that the drag forces of the lower extremities in water cause significant changes in gait patterns, walking speeds and muscle activity compared to land walking (Alkurdi et al., 2010; Gleim & Nicholas,1989; Pohl & McNaughton, 2003). Furthermore, although water walking, running or exercising is beneficial, not everyone is comfortable getting into the water or wearing a bathing suit, additionally there may not be a pool available, making this an unsuitable modality.

More recently, lower body positive pressure (LBPP) devices have been researched as they resemble land walking and may be a more convenient modality for rehabilitation, to reduce lower extremity stress as a result of overweight and obesity as well as support improvements in cardiovascular health. LBPP devices to support body weight during walking such as harness suspension systems have demonstrated walking requires less metabolic power (Grabowski, Farley, & Kram, 2005; Farley & McMahon, 1992; Griffin, Tolani, & Kram,1999). However these systems can be uncomfortable and inhibit circulation in the individual and may not be a favorable modality for long-term use (Grabowski, 2010). Grabowski & Kram, 2008, used a LBPP device called the G-trainer to determine the separate and combined effects of speed and weight support on ground reaction forces (GRFs) and metabolic power during running and concluded that GRFs are reduced at all levels of weight support. In addition, for any given amount of weight support, metabolic demand can be increased, by increasing running speed, but for any given running speed, weight support reduced metabolic demand. Therefore, running at fast speeds with weight support will maintain cardio respiratory demands ultimately reducing GRFs.

A major advantage of the G-trainer or AlterG® is walking and running kinematics are more similar to normal walking and running than in the water or on harness systems (Cutuk, et al., 2006; Grabowski & Kram, 2008). It also allows an overweight or obese individual to walk at a lower percentage of their body weight helping to reduce stress on lower extremities. Finally, it is a more reliable method where the amount of weight that is changed can be recorded in a more precise manner. To date, there is limited data that currently exists on the effects of LBPP treadmill walking on overweight and obese men and women. Furthermore, little evidence exists on energy expenditure utilizing the AlterG® in obese individuals. Potential decreases in body fat and increases in lean body mass in overweight and obese individuals following reduced gravity treadmill training may enhance health benefits. Therefore, the type of activity and its' effects on energy expenditure have important implications to develop strategies as well as decrease injury that address the obesity epidemic. The purpose of this study aimed to investigate the effect of body composition on energy expenditure while walking with body weight support.

2. Methods

2.1 Subjects

Eighteen men, classified as overweight or obese (BMI > 25 kg/m^2, %body fat > 22%) (CDC, 2016; ACSM, 2014) were recruited for this study, which was approved by Seton Hall University and William Paterson University's Institutional Review Board. Two participants did not meet the inclusion criteria and three ended up dropping out due to lack of time. Thirteen participants gave written informed consent after the experimental procedures were explained to them. To standardize the testing conditions and to insure safety of the subject, the following pre-test instructions were given to each subject before their first visit: (1) Abstain from eating 12 hours before the test (2) Abstain from consuming caffeine-containing products for a minimum of 12 to 24 hours before the test (3) Abstain from strenuous exercise for at least 24 hours before the test, and (4) Consult the researcher on the potential use of any over the counter medication as some may affect resting or exercise heart rate and may affect test accuracy. To obtain a power of 0.8 at alpha < 0.05 with a large effect size, a paired samples *t*-test for two treadmill conditions (walking at 100% BW and 75% BW) was based on a priori calculation where a sample size of 15 subjects was required to determine TEE, EEFM, and EEFFM between two treadmill conditions (G*Power Version 3.1.5).

2.2 General Design

The participants attended the laboratory for two sessions separated by at least three but not more than seven days following the anthropometric and body density measurements. All sessions took place in the same laboratory where air temperature was 24.1 ± 3°C and relative air humidity was 20° ± 5%. **Session 1 - (Anthropometric Measurements and Body Density):** Participants reported to the Human Performance Lab at William Paterson University where baseline measures of height, weight, waist and hip circumference and body density were measured. Body composition was determined by measuring body density using hydrostatic weighing. **Session 2 and 3: Exercise Test:** At both sessions, subjects were familiarized with the equipment and procedures. The subjects reported to the laboratory after a 12-hour overnight fast and at approximately the same time for each of the two sessions to avoid variations in their circadian rhythms. Resting blood pressure was recorded and then the subjects were prepped for ECG placement to determine resting and exercise heart rates. Subjects were then fitted with a mask connected to a metabolic cart to collect expired gases to determine $\dot{V}O_{2max}$. Subjects were then instructed to put on the neoprene shorts and then they were zipped in to the treadmill aperture. Before the test, the air pressure in the chamber adjusted to apply the proper lifting force for each subject by way of a built in pressure feedback system. The treadmill tests were randomized where the subject began on the AlterG® at either 100% or 75% of their body weight.

After the calibration process a warm up of 2.0 mph for 3 minutes at 100% body weight was performed. The participants, in random order (100% or 75% BW) began to walk at 3.3 mph at 0% grade. The speed was held constant for the duration of the test where the gradient increased every 3 minutes by 3% up to 15% grade. Heart rate and RPE were recorded during the last 5 seconds of each stage and blood pressure was recorded during the last 30 seconds of each stage. The test was terminated if the participant experienced adverse signs or symptoms (ACSM, 2014) or requested to stop. Additionally, participants believed to have reached their true $\dot{V}O_{2max}$ if the following conditions exist: (a) a plateau in $\dot{V}O_2$ (b) a heart rate within 5-10 beats of their age-predicted maximal heart rate (220-age x .85), (c) RPE of 18-20 and (d) a respiratory exchange ratio (RER) of 1.10. All subjects participated in two tests on two separate days separated by at least three but no more than seven days once informed consent and the PAR-Q have been completed. The two tests were randomized and performed on the AlterG® anti-gravity treadmill at two different percentages of the subjects' original body weight (100% and 75%) to determine $\dot{V}O_{2max}$, and HR.

2.3. Statistical Analysis

Differences between the two treadmill conditions (100% BW & 75% BW) for the following dependent variables: Total Energy Expenditure for 18 minutes of walking (TEE_{18}), Energy Expenditure Fat Mass (EE_{FM}), Energy Expenditure Fat Free Mass (EE_{FFM}) were performed using a paired samples *t* –test. All data were recorded and uploaded into Microsoft® Excel (version 14.4.1). Statistical analysis was performed using the SPSS IBM statistical package (v. 23, Chicago, IL). A Kolmogorov-Smirnov & Shapiro Wilk test for normality was completed on all variables to determine homogeneity of variances.

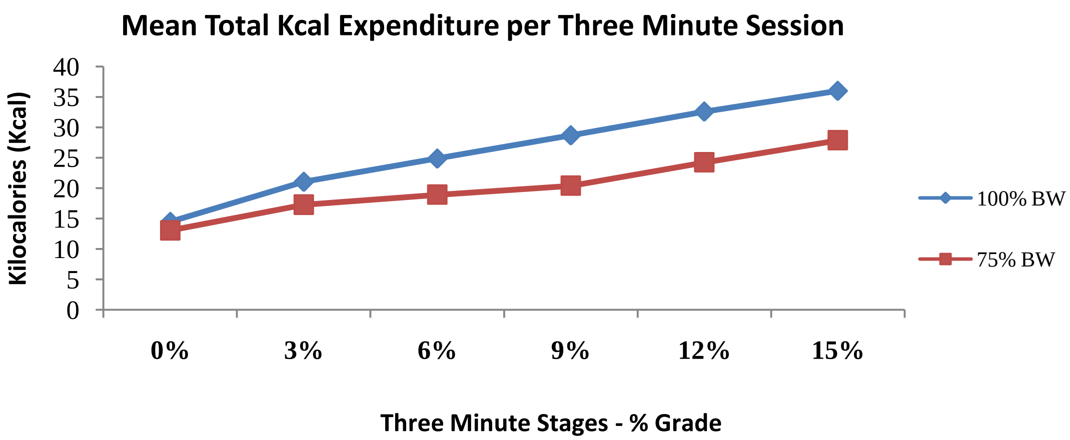
3.Results

The results are presented as mean ± standard deviation. Calculation of Cohen's d effect size values for *t*-tests were classified as small (0.2), medium (0.5) and large (>0.8). Effect size calculations for all dependent variables were analyzed in G*Power 3.1 and were found to was found to exceed Cohen's (1988) convention for a large effect (*d* = .80) suggesting a high practical significance (Faul, Erdfelder, Buchner, & Lang, 2009). Physical characteristics of the study participants are summarized in Table 1. Kolmogorov-Smirnov & Shapiro Wilk tests of homogeneity of variances were done on the dependent variables, TEE, TEE_{18min}, EE_{FM}, EE_{FFM}. The tests showed no significant differences between groups, indicating normality of distributions. In order to compare difference scores between the two levels of the independent variables (100% BW and 75% BW) on the AlterG® anti-gravitytreadmill, a paired samples *t*-test was conducted on all dependent variables. Table 2 summarizes the mean ± SD values for 13 participants on TEE_{18min}, EE_{FM}, $EE_{FFM}$for each BW condition, which was obtained in the last minute of the last stage.

1. Descriptive statistics for 13 participants.

	N	Minimum	Maximum	Mean	St. Deviation
Age (y)	13	20	28	23.23	2.52
Height (m)	13	1.63	1.87	1.74	0.07
Weight (kg)	13	88.5	145.82	110.79	16.81
BMI (kg/m^2)	13	32.5	44.1	36.40	3.90
Bodyfat (%)	13	27.4	56	38.06	7.44
FFM (kg)	13	54.98	78.12	67.84	7.56
FatMass (kg)	13	24.78	81.66	45.27	17.26

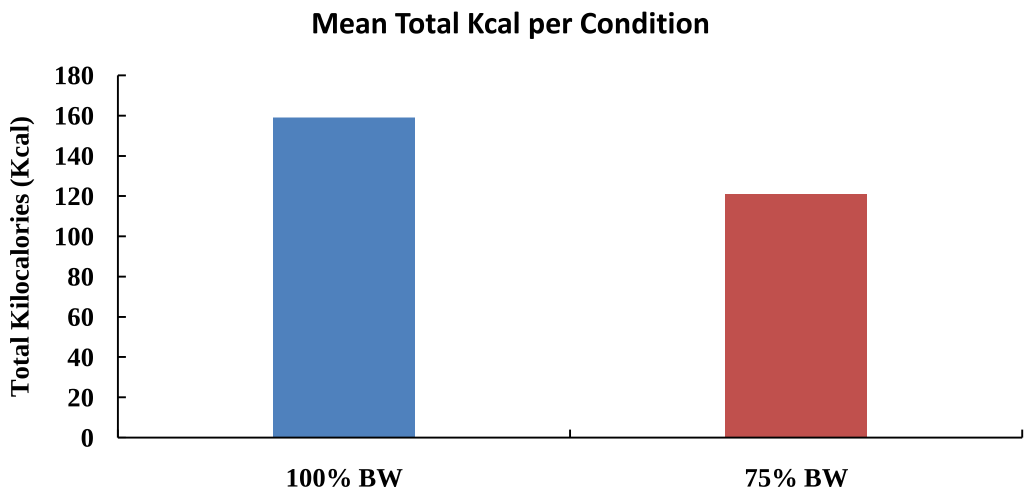
Figure 1. Energy expenditure (Kilocalories) as exercise intensity increases.



3.1. Total Energy Expenditure ($TEE_{18\ minutes}$)

Figure 1 depicts an incremental increase in energy expenditure as workload increases in both BW conditions for the duration of the exercise session. Total energy expenditure for the entire 18 minute session peaked at 159.03 ± 37.24 Kcal in the 100% BW group and peaked at 120 ± 41.33 Kcal in the 75% BW group. A paired samples *t*-test showed the difference in TEE_{18} min between the 100% BW and 75% BW condition were statistically significant, ($t(12) = 5.31$, $p < 0.05$), 95% *CI* (22.66, 53.94), d= 1.47. Figure 2 shows the difference between the two treadmill conditions where participants in the 100% BW group reached a higher TEE18 (*M* = 159.03, *SD* = 37.24) than the 75% BW group (*M*= 120, *SD* = 41.33).

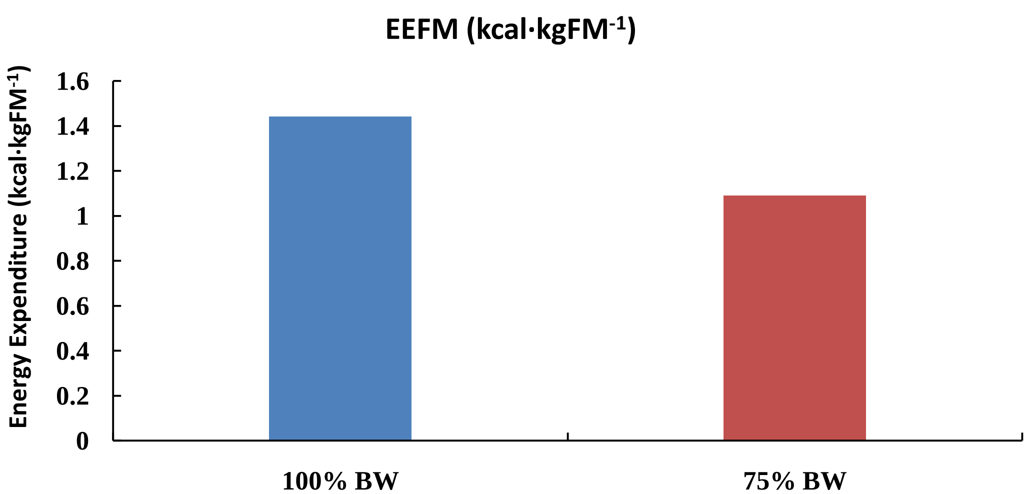
Figure 2. Mean total kilocalories expended per body weight condition.



3.2. Energy Expenditure Fat Mass (EE_{FM})

A paired samples *t*-test showed a statistically significant difference in EE_{FM} between the 100% BW condition and the 75% BW condition, (t (12) = 5.29, $p < 0.05$), *95% CI (.208, .499)*, d=1.4. Figure 3 shows the difference between the two treadmill conditions where participants in the 100% BW group experienced statistically significant higher EE_{FM} (*M* = 1.44, *SD* =.26) than the 75% BW group (*M*= 1.09, *SD* = .29).

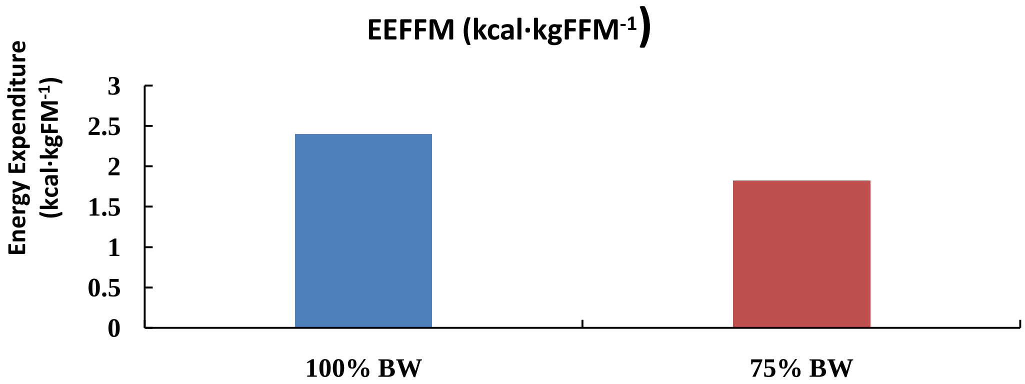
Figure 3. Energy expenditure relative to fat mass per body weight condition.



3.3 Energy Expenditure Fat-Free Mass (EE_{FFM})

A paired samples *t*-test showed a statistically significant difference in EE_{FFM} between the 100% BW condition and the 75% BW condition, (t (12) = 5.158, $p < 0.05$), *95% CI (.333, .819)*, d=1.4. Figure 4 shows the difference between the two treadmill conditions where participants in the 100% BW group experienced statistically significant higher EE_{FFM} (*M* = 2.40, *SD* =.74) than the 75% BW group (*M*= 1.8*SD* = .75).

Figure 4. Energy expenditure relative to fat free mass per body weight condition.



4. Discussion

Obese individuals typically have low levels of physical activity resulting from low or no participation in exercise due to excess weight on the lower extremities, which can cause alterations in gait, resulting in pain while walking (Losina, Walensky, Reichmann et al., 2011). The purpose of this study was to determine the effects of body composition on energy expenditure in men classified with obesity as they are walking on a LBPP treadmill at 75% compared to 100% of their body weight. The main finding of this study was that energy expenditure is higher in the 100% body weight condition (159 ± 37 Kcal) compared to the 75% body weight condition (120 ± 41 Kcal). More specifically, energy expenditure was 39 Kcal lower in the 75% BW condition. Although the American College of Sports Medicine (2014) recommends 300 to 500 kilocalories per day for weight loss, those in the 75% BW group expended 120 kilocalories for 18 minutes. Figure 1 shows that as exercise intensity increases so does energy expenditure, therefore, if they were to walk for 30 to 40 minutes (200 kcal to 266 kcal) they could meet just below the minimum requirements for weight loss without the stress on the lower body. Average body fat for those in the current study was 38% and as a result we decided to look at the effect of body composition, specifically $EE_{FM}$and EE_{FFM}. The 100% BW condition demonstrated a greater EE_{FM} ($M = 1.44 \pm .2$ kcal/kg_{FM}) compared to the 75% BW condition ($M = 1.09 \pm .3$ kcal/kg_{FM}) meaning the 75% BW condition transported less non-metabolic tissue. Furthermore, the 100% BW condition also demonstrated a greater EE_{FFM} (M=2.40 ± .7 kcal/kg_{FFM}) compared to the 75% BW condition (M=1.8 ± .7 kcal/kg_{FFM}). Loftin, Waddell, Robinson and Owens (2010) looked at energy expenditure in walking and running a mile that included overweight men and women. They reported values of 1.64 kcal/kgFFM in the overweight group following a 1-mile walk, which is similar to the current study except that our results are over time not distance.

Miller and Stamford (1987) noted that higher energy expenditure was observed as moderately trained men and women walked at 2 to 4 mph with hand and ankle weights of 9 kg compared to running at 5 to 7 mph without weights. Additionally, Mayhew et al., (1979) examined energy expenditure when expressed per kilometer, in trained and untrained men. The untrained men weighed 10.6 kg more than the trained men and found that they expended more kilocalories compared to the trained men. Therefore, whether one is overweight, obese or added body weight such as wrist or ankle weights, or a weighted backpack, energy expenditure is increased in a normal weighted environment.

In an un-weighted environment Grabowski, (2010), Figueroa et al., (2011) and Raffalt et al., (2013) found that as body weight decreased there was a significant decrease in energy expenditure. When the energy expenditure is decreased this may indicate exercise tolerance increases and time to exhaustion can be longer. A case study by Simonson, Shimon, Long, &Lester, (2011) looked at the effects of a 14-week walking program on the LBPP treadmill on an individual with morbid obesity. The exercise program was of moderate intensity (40 to 60% HRR) and the results demonstrated the subject was able to increase the duration of the exercise program from 10 minutes to 65 minutes. Although no significant weight loss was observed, the participant's exercise tolerance and activity levels increased.

5. Conclusion

Exercise interventions targeting reduction of body fat, improvements of overall health and injury prevention are essential in weight management to combat the obesity epidemic. Overweight or obese individuals typically have poor cardio respiratory endurance, and may have a number of issues in the lower extremities that make exercising more difficult. According to the ACSM (2014), non-weight bearing modalities have been recommended to minimize injury. Exercise training in a reduced gravity environment such as the AlterG® can be an optimal modality for obese individuals. Research on the LBPP treadmill has shown that by manipulating velocity and weight support, ground reaction forces are reduced without restrictions on movements as well as maintaining cardio respiratory demand. (Figueroa, Manning & Escamilla, 2011; Grabowski, 2010; Grabowski & Kram, 2008; Raffalt, Howaard-Hansen, & Jensen, 2013). The LBPP treadmill has demonstrated that it was effective in increasing caloric expenditure and over time may have indirect effects on weight reduction by enabling exercise in individuals otherwise unable to do so. Finally, walking on the LBPP treadmill is encouraged to increase energy expenditure and reduce health risks, while taking undo stress off the lower extremities.

5.1 Limitations

This study involved healthy male subjects between 20 and 28 years old and therefore conclusions cannot be generalized to other patient populations. Another limitation was that diet and activity levels were not monitored and sample size was small. Finally, those who are characterized as extremely obese may not fit into the shorts.

5.2 Future Recommendations

The current research provides a starting point for investigating LBPP and caloric expenditure in individuals with obesity. Areas that require further investigation in the un-weighted environment are continued high quality research such as randomized control trials, in a variety of populations to validate recommendations for exercise training and caloric expenditure. Furthermore, there is limited research on the caloric expenditure of training on a LBPP device and more studies are needed to identify optimal training protocols for weight reduction in individuals with obesity. Finally, exercise professionals need to choose methods that are appropriate to assist individuals with obesity achieve health goals.

References

Alkurdi, W., Paul, D.R., Sadowski, K., & Dolny, D.G. (2010). The effect of water depth on energy expenditure and perception of effort in female subjects while walking. *International Journal of Aquatic Research and Education, 4*, 49-60.

American College of Sports Medicine. (2014). *ACSM's Guidelines for Exercise Testing and Prescription* (9th ed.). Baltimore, MD; Lippincott Williams and Wilkins.

Browning, R.C., Baker, E.A., Herron, J.A., & Kram, R. (2005). Effects of obesity and sex on the energetic cost and preferred speed of walking. *Journal of Applied Physiology,* doi:10.1152/japplphysiol.00767.2005

Bloom, W.L. & Marshall, F.E. (1967). The comparison of energy expenditure in the obese and lean. *Metab olis m* 16, 685–692.

Browning, R.C., &Kram, R. (2007). Effects of obesity on the biomechanics of walking at differ rent speeds. *Medicine Science in Sports and Exercise, 39*(9), 221-228.

Centers for Disease Control (2015). *Overweight and Obesity*. Retrieved from https://www.cdc.gov/ obesity/ data adult.html

Cohen J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed) New York, NY: Routledge Academic

Cutuk, A., Groppo, E.R., Quigley, E.J., White, K.W., Pedowitz, R. A. & Hargens, A.R. (2006). Ambulation in simulated fractional gravity using lower body positive pressure: cardiovascular safety and gait analysis. *Journal of Applied Physiology*, *101*(3), 771-777. doi: 10.1152/japplphysiol.00644-2005

Farley, C. T., & McMahon, T. A. (1992). Energetics of walking and running: insights from simulated reduced-gravity experiments. *Journal of Applied Physiology*, *73*(6), 2709-2712.

Felson, D.T., Anderson, J.J., Naimark, A., Walker, A.M., and Meenan, R.F. (1988). Obesity and knee steoar thritis: the Framingham study. *Annuals of Internal Medicine,* 109, 18– 24.

Figueroa, M.A., Manning, J., & Escamilla, P. (2011). Physiological responses to the AlterG® anti-gravity treadmill. *International Journal of Applied Science and Technology, 1*(6), 92-97.

Foster, G.D., Wadden, T.A., Kendrick, Z.V., Letizia, K.A., Lander, D.P., & Conill, A.M. (1995). *The energy cost of walking before and after significant weight loss. Medicine Science Sports and Exercise* 27 *:* 888–*894*, 1995.

Gleim, G. W., & Nicholas, J. A. (1989). Metabolic costs and heart rate responses to treadmill walking in water at different depths and temperatures. *The American Journal of Sports Medicine, 17,* 248-252.

Grabowski, A. (2010). Metabolic and biomechanical effects of velocity and weight support using a lower body positive pressure device during walking. *Archives of Physical Medicine and Rehabilitation. 91*, 951-957.

Grabowski, A. &Kram, R. (2008). Effects of velocity and weight support on ground reaction forces and metabolic power during running. *Journal of Applied Biomechanics, 24*:288-297.

Grabowski, A., Farley, C.T., &Kram, R. (2005). Independent metabolic cost of supporting body weight and accelerating body mass during walking. *Journal of Applied Physiology*, *98*,579-583. oi:10.1152/japplphy siol.00734.2004.

Greene, N.B., Lambert, G.S., Greene, E.S., Carbuhn, A.F., Green, J.S. &Crouse, S.F. (2009). Comparative efficacy of water and land treadmill training for overweight or obese adults. *Medicine and Science in Sports Exercise*, *41*, 1808-1815.

Griffin, T.M., Roberts, T.J., & Kram, R. (2003)Metabolic cost of generating muscular force in human walking: insights from load-carrying and speed experiments. *Journal of Applied Physiology* 95, 172–183.

Griffin, T.M., Tolani, N.A., &Kram, R. (1999). Walking in simulated reduced gravity: mechanical energy fluct uate ons and exchange. *Journal of Applied Physiology* 86(1), 383–390.

Lafortuna, C.L., Agosti, F., Galli, R., Busti, C., Lazzer, S., & Sartorio, A. (2008). The energetic and cardiovas cular response to treadmill walking and cycle ergometer exercise in obese women. *European Journal of Applied Physiology*, *103*(6): 707-717.

Lelas, J.L., Merriman, G.J., Riley, P.O., & Kerrigan D.C. (2003). Predicting peak kinematic and kinetic parameters from gait speed. *Gait Posture 17*, 106–112.

Losina, E., Walensky, R., Reichmann, W. et al. (2011). Impact of obesity and knee and osteoarthritis on morb idit y and mortality in older americans. *Annuals of Internal Medicine, 154*(4), 217-226.

Matts son, E., Larsson, U.E., &Rossner, S. Is walking for exercise too exhausting for obese women ? *Inter nation al Journal of Obesity Related Metabolic Disorders* 21,380–386.

Mayhew, J.L., Piper F.C., & Etheridge, G.L. (1979). Oxygen cost and energy requirement of running in trained and untrained males and females. *Journal of Sports Medicine and Physical Fitness*, *19*(1), 39-44

Melanson, E.L., Bell, M.L., Knoll, J.R., Coelho, L.B., Donahoo, W.T., Peters, J.C., &Hill, J.O. (2003). Body mass index and sex influence the energy cost of walking at self- selected speeds (Abstract). *Medicine Science Sports Exerc*ise, *35*, S183.

Miller, J.F. & Stamford, B.A. (1987). Intensity and energy cost of weighted walking vs. running for men and women. *Journal of Applied Physiology*, 62, 1497-1501.

National Heart, Lung, and Blood Institute (NHLBI), National Institutes of Health (NIH) (1998). Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults. The evidence report. NIH Publication No 98-4083, National Institutes of Health. Retrieved from http://www.nhlbi.nih.gov/ guidelines/obesity/ob_gdlns.pdf

Pohl, M.B., & McNaughton, L.R. (2003). The physiological responses to running and walking in water at different depth. *Research in Sports Medicine*, *11*, 63-78.

Raffalt, P.C., Howgaard-Hansen, L. & Jensen, B.R. (2013). Running on a lower-body positive pressure treadmill: Peak VO2, respiratory response, and vertical ground reaction force. *Research Quarterly for Exercise and Sport, 84*, 213-222.

Silvers, W. M., Rutledge, E. R., &Dolny, D. G. (2007). Peak cardiorespiratory responses during aquatic and land t readmill exercise. *Medicine and Science in Sports andExercise, 39,* 969-975.

Thompson, D.L., Townsend, K.M., Boughey, R., Patterson, K., & Bassett Jr., B.R. (1998). Substrate use during and following moderate and low-intensity exercise: Implication for weight control. *European Journal of Applied Physiology*, *78*, 43-49.

Wing, R.R. (1999). Physical activity in the treatment of adulthood overweight and obesity: current evidence and research issues. *Medicine Science in Sports and Exercise*, *31*, 547-552. World Health Organization (2016). *Obesity*. Retrieved from http://www.who.int/topics/obesity/en/