Physiological Responses of Walking on a Lower Body Positive Pressure Treadmill in Males Classified as Obese.

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Abstract

Purpose: *To investigate physiological responses to walking at 100% to 75% while on a lower body positive pressure treadmill (LBPP).* ***Results:*** *and Heart rate (HR), rate of perceived exertion (RPE) and peak oxygen consumption ($\dot{V}O_{2peak}$)were significantly lower($p<.05$) at 75% BW compared to 100% BW.* ***Conclusion:*** *Unweighting on the LBPP can be used as a low to moderate intensity exercise for obese individuals to sustain physical activity and improve one's exercise tolerance resulting in an improved quality of life.*

Keywords: lower body positive pressure treadmill, maximal/peak oxygen consumption, heart rate, rate of perceived exertion, obese.

1. Introduction

$\dot{V}O_{2max}$ is a measure of cardio respiratory fitness (CRF) and is defined as the ability of the circulatory, respiratory, and muscular systems to supply oxygen during sustained physical activity. Physical activity is defined as any bodily movement produced by skeletal muscles that require energy expenditure, where exercise is defined as physical activity that is planned, structured, repetitive, and purposeful. Physical activity includes exercise as well as playing, working, getting from one place to another, household chores, and recreational activities (WHO, 2016).Lack of physical activity or physical inactivity has been identified as a risk for coronary heart disease, hypertension, dyslipidemia, stroke, liver, and gallbladder disease, respiratory problems and sleep apnea. It is also the main cause of approximately 21 to 25% of breast and colon cancers, 27% of diabetes and approximately 30% of ischemic heart disease as well as 6% of deaths globally (WHO, 2016).

Furthermore, lack of physical activity is also associated with orthopedic and psychosocial problems, all of which frequently result in an increase in healthcare costs (CDC, 2011).Evidence-based clinical guidelines on obesity management support that physical activity can lower co morbidities related to obesity(Booth, Roberts, & Laye, 2012; Kodama, Saito, Tanaka, Maki, & Yachi, et al., 2009; Winett, & Carpinelli, 2000).Moreover, recent investigations based on current physical fitness recommendations concluded that being physically fit as indicated by $\dot{V}O_{2max}$was more strongly associated with a marked reduction in all-cause mortality risk than physical activity(Lee, Sui, Ortega, Kim, Church, et al., 2011;Wen, Wai, Tsai, Yang, Cheng, et al., 2011). Fogelholm,(2010) conducted a systematic review and concluded that low levels of physical activity in unfit individuals resulted in a greater all-cause and mortality risk than obesity in an individual who is physically fit.

To follow-up, McAuley, Kokkinos, Oliveira, Emerson, and Myers, (2010) evaluated 12,417 male veterans aged 40 to 70 years with known or suspected coronary heart disease and found that overweight and obese men with moderate cardio respiratory fitness had mortality rates similar to those of the highly fitnormal-weight group. As a result, it has been suggested that improving $\dot{V}O_{2max}$ is more important than losing weight or participating in lower to moderate intensity physical activity (Lee et al., 2011; Gaesser, 1999).

Exercise intensity is one of the most important and problematic factors in prescribing exercise for obese individuals. To individualize an exercise prescription, relative exercise intensity based on a measured or estimated maximal/peak oxygen uptake($\dot{V}O_{2max/peak}$) is commonly measured and expressed as ml/kg/min. Some other methods include, heart rate reserve (HRR), percentage of heart rate maximum (%HR_{max}), oxygen uptake reserve ($\dot{V}O_2$R)and rate of perceived exertion (RPE)(ACSM, 2014). Currently, the American College of Sports Medicine (2014) recommends $\dot{V}O_{2max}$, HRRand/or RPE to prescribe intensity. For the overweight and obese population moderate exercise intensity is recommended at the start of an exercise program (40% to < 60% $\dot{V}O_2$ R or HRR and/or an RPE 11-13) then progress to a more vigorous intensity (60% to < 85% $\dot{V}O_2$ R or HRR and/or an RPE 14-16) for a minimum of 30 minutes per day increasing to 60 minutes.

Although regular physical activity has proven health benefits for overweight and obese individuals, weight bearing exercise with an excess of body weight (Body Mass Index (BMI) > 35 kg/m^2) may increase the potential for injury or exacerbate existing joint conditions and may result in a loss of interest in exercise. For these individuals, non-weight bearing modalities should be encouraged to minimize injury at a moderate to vigorous intensity. Some of the non-weight bearing low impact exercise devices and protocols that utilize large muscle groups have emerged on the market and in the literature include aquatic exercise and lower body positive pressure modalities.

Aquatic exercise has been shown to reduce stress on the joints and improve aerobic capacity (Greene et al., 2009).In addition, the hydrostatic effects of water, increases central venous pressure, stroke volume, and cardiac output, which is caused by a shift in blood volume from the periphery to the thorax (Arborelius, Balldin, Lija, & Lundgren, 1972). This increase leads to a decrease in heart rate response during aquatic exercise. Two studies evaluated the effect of water depth on metabolic cost and heart rate responses (Gleim& Nicholas, 1989; Pohl & McNaughton, 2003). Gleim and Nicholas (1989) tested six men and five women with a mean age of 27.5 on the underwater treadmill (UTM) at 6.44 kph in four different water depths. Water levels at the ankle, patella, and mid-thigh required greater oxygen consumption than water levels that are at waist level. Pohl and McNaughton (2003) compared walking 4.02 kph in a water depth of waist and thigh high. It should be noted that $\dot{V}O_2$ in their study was lower than the study of Gleim and Nicholas (1989), which was probably due to the water depth and characteristics of the subjects. However, both studies confirmed that as water depth decreased, $\dot{V}O_2$ and HR significantly increased. Alkurdi, Paul, Sadowskly and Dolny(2010), observed that minor changes in water depth (±10cm) significantly influenced energy expenditure, HR and RPE regardless of walking speed. These results are consistent with Gleim and Nicholas (1989) and Pohl and McNaughton (2003). In addition, water at chest level combined with the hydrostatic pressure has been shown to be up to 20 bpm lower in water than on land (Mougios & Deligiannis, 1993). Furthermore, the lower the water below the waist, the greater the metabolic cost, and when water is at waist level or higher, metabolic cost decreases (Gleim & Nicholas 1989; Pohl & McNaughton, 2003).

A limitation of walking in water is that drag forces of the lower extremities cause significant changes in gait patterns, walking speeds and muscle activity compared to land walking (Alkurdi et al., 2010; Barela, Stolf & Duarte, 2006; Chevutschi, Alberty, Lensel, Pardessus, & Thevenon, 2009).As a result, two factors influence energy expenditure, drag resistance and hydrostatic force supporting body weight (Alkurdi et al., 2010). A lower pressure positive pressure device (LBPP), called the AlterG®anti-gravity treadmill, developed by NASA is currently being used in rehabilitation of lower extremity injuries, spinal cord injuries, and strokeand may be an alternative for the overweight/obese population. The AlterG® uses differential air pressure to apply a lifting force to the subject's lower body allowing for the manipulation of unweighting up to 80% of an individual's body weight. Although the aperture is zipped in at the iliac crest, the AlterG® eliminates the drag forces of the legs, allowing for similar gait patterns to normal weight land walking, does not impede circulation is more comfortable, adjustable and can be used for extended periods of time (Grabowski, 2010). Recent investigations (Aaslund & Moe-Nilssen, 2008; Cutuck, et al., 2006; Figueroa, Manning, & Escamilla, 2011; Grabowski, 2010; Grabowski &Kram, 2008; Raffalt, Howgaard-Hansen, & Jensen, 2013;) demonstrate favorable changes in physical activity levels, exercise tolerance with similar results in cardio respiratory responses compared to over-ground walking.

While these findings support anti-gravity training as having positive changes in health outcomes in healthy individuals, further investigation is required to assess its effectiveness in the overweight and obese individual.

1.2 Purpose of the Study

The purpose of this study was to investigate the $\dot{V}O_{2max}$ and heart rate (HR) while walking on the AlterG® anti-gravity treadmill at 75% body weight in men classified as obese.

2. Methods

2.1 Subjects

Eighteen men, classified as overweight or obese (BMI > 25 kg/m^2, %body fat > 22%) (CDC, 2012; 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 two ended up dropping out due to lack of time. Fourteen 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, the paired samples *t*-test for two treadmill conditions (walking at 100% BW and 75% BW) was based on a priori calculation that was determined in a pilot study. A sample size of 6 subjects was required to determine $\dot{V}O_2$ and HR 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 underwater 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: $\dot{V}O_{2max}$, HR and RPE during each stage of exercise 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. 19, 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 and mean ± standard error of the mean. Results were analyzed using the statistical package SPSS version 19.0, Chicago, Illinois. 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 (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, $\dot{V}O_2$ and HR. 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 variable (100% BW and 75% BW) on the AlterG® anti-gravitytreadmill, a paired samples *t*-test was conducted on $\dot{V}O_2$ and HR. Table 2 summarizes the mean ± SD values for 14 participants on peak HR, $\dot{V}O_2$ and RPE for each BW condition, which was obtained in the last minute of the last stage.

3.1. Oxygen Consumption ($\dot{V}O_2$)

Oxygen consumption peaked at 23.07 ml/kg/min in the 100% BW group and peaked at 17.69 ml/kg/min in the 75% BW group. A paired samples *t*-test showed the difference in $\dot{V}O_{2\,peak}$ between the 100% BW and 75% BW condition were statistically significant, ($t(13) = 3.97$, $p < 0.05$), 95% *CI* (2.45, 8.31), $d = 1.06$. The effect size of 1.06 and was found to exceed Cohen's (1988) convention for a large effect ($d = .80$) suggesting a high practical significance. Figure 1 shows the difference between the two treadmill conditions where participants in the 100% BW group reached a higher $\dot{V}O_{2peak}$($M = 23.07$, $SD = 4.23$) than the 75% BW group ($M = 18.70$, $SD = 3.72$).

3.2. Heart Rate (HR)

A paired samples *t*-test showed a statistically significant difference in HR between the 100% BW condition and the 75% BW condition, ($t(13) = 3.0$, $p < 0.05$), *95% CI (4.44, 27.28), d*= .80. The effect size of .80 and was found to exceed Cohen's (1988) convention for a large effect ($d = .80$). A power analysis based on the large effect size of .80 at a α of .05 revealed the probability of finding a difference 80% of the time between the two treadmill conditions. Figure 1 shows the difference between the two treadmill conditions where participants in the 100% BW group experienced statistically significant higher heart rates ($M = 157.10$, $SD = 2.49$) than the 75% BW group ($M = 141.30$, $SD = 2.02$).

3.3. RPE

Rate of perceived exertion (RPE) is an ordinal scale where each participant is asked to rate his level of exercise intensity based on how hard they feel they are working. As a result, a Wilcoxon matched pairs signed-rank test was conducted to determine whether there was a difference in the RPE between the 100% BW condition and the 75% BW condition. The test showed that changes in body weight did elicit statistically significant changes in perceived effort ($z = -2.15$, $p < 0.05$), $r = .68$ (Figure 2). The effect size is above the 0.5 threshold for a large effect at an α of .05 with a desirable power of .62 which indicates the probability of finding a difference 62% of the time between the two treadmills. Figure 2 shows the difference between the two treadmill conditions where 11 participants in the 100% BW group perceived their effort to be greater ($M = 14.0$, $SE = .42$) than the 75% BW group ($M = 12.57$, $SE = .71$). Furthermore, 3 participants perceived a greater effort at 75% BW and one participant reported the same amount of effort at peak exercise for both conditions.

4. Discussion

The purpose of this study was to determine physiological responses in men classified with obesity as they are walking on a LBPP treadmill at 75% of their body weight. The main finding of this study was that subjects did not reach their $\dot{V}O_{2max}$due to the length of the test but did reach a $\dot{V}O_{2peak}$, which refers to the highest value of $\dot{V}O_2$ that was attained during this study. Other findings were that there were significant differencesin $\dot{V}O_{2peak}$

HR and RPE when walking on the LBPP treadmill at 100% BW compared to 75% BW. In the present study, we observed that in the 75% BW condition, $\dot{V}O_2$ peaked at 17.69 ± 2.4 ml/kg/min at a mean HR of 141.30± 2 which resulted in a significant decrease from the 100% BW condition. Mean HR for the 100% BW condition was 155 ± 23 bpm compared to the 75% BW condition at 149 ± 20 bpm where heart rates between conditions demonstrated a significant difference.

Although heart rates increased linearly in both conditions as workload increased, the 75% BW condition demonstrated a significant decrease in the slope compared to the 100% BW condition. It is interesting to note that four participants in the 100% BW group exceeded 85% of their maximal heart rate (HR_{max}) which suggested the exercise intensity was too much for them. Six participants were 20 to 40 beats below their 85% of HR_{max} indicating the intensity was not enough and the remaining four were at or close to 85% of their HR_{max}. For the 75% BW group, only three participants reached 85% of their HR_{max} and the remainder of the participants were below indicating that the intensity of exercise was comfortable and at a low to moderate intensity. Furthermore, walking at 75% of one's BW enables the individual to reach their target heart rate at a lower HR and perceived effort (Grabowski, 2010; Figueroa et al., 2011; Lafortuna, Agosti, Galli, Busti, & Lazzer, 2008; Raffalt et al., 2013).

The Borg Rating of Perceived Exertion (RPE) is another way of measuring physical activity intensity level. Perceived exertion is a subjective measure as to how hard you feel like your body is working. This is based on the physical sensations a person experiences during physical activity, including increased heart rate, respiration or breathing rate, increased sweating, and muscle fatigue. Although this is a subjective measure, the amount of exertion an individual may feel, has been found to be a fairly good estimate of the actual heart rate during physical activity (Borg, 1967).Jakicic, Donnelly, Pronk, Jawad and Jacobsen (1995) examined the relationship between %HRR, %$\dot{V}O_{2peak}$, and RPE in obese females. They found that %HRR and %$\dot{V}O_2$ corresponded to RPE values of 13-14 with an intensity of 40-70%HRR and $\dot{V}O_{2peak}$.There is general agreement that perceived exertion ratings between 12 to 14 on the Borg Scale suggests that physical activity is being performed at a moderate level of intensity (Borg, 1998).

The results of this study are consistent with Jakicic et al., (1995) where mean RPE was at 12.57 indicating a moderate intensity in the 75% BW group. The 100% BW group had a mean RPE of 14 also indicating a moderate intensity on the higher end of the range. Grabowski, (2010), Figueroa et al., (2011) and Raffalt et al., (2013) also found that as body weight decreased; there was a significant decrease in RPE. When the RPE is decreased this may indicate exercise tolerance increases and time to exhaustion can be longer. Acase 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.

For those interested in weight control and cardiovascular health, exercise in the range of 40 to <60% of $\dot{V}O_2R$ or HRR or 64 to 76% of HR_{max}, with an RPE of 12-14 is currently suggested by the American College of Sports Medicine (2014). Subjects in the 75% BW group reached a mean $\dot{V}O_{2peak}$ of 17.69 ml/kg/min, aHR_{peak} of 149± 20 bpm and RPE of 12.57, which indicates that participants were in the moderate intensity range according to the American College of Sports Medicine (2014).If these participants were able to go longer at that intensity, and the goal were to lose weight, the rate of weight loss may be dependent on the duration of the exercise session.

5. Conclusion

The epidemic of overweight and obesity is one of the most significant problems facing the US health care system today. Physical activity is regarded as a respected tool in the treatment and management of obesity and should be a part of all weight maintenance programs (Donnelly et al., 2009). For those who are obese, increasing physical activity on a regular basis is difficult, painful, and frustrating, especially if the mode of activity is walking. As a result, it is important to find a protocol that allows obese individuals to sustain physical activity over a period of time. According to the ACSM (2014), non-weight bearing modalities have been recommended to minimize injury. 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 et al., 2011; Grabowski, 2010; Grabowski &Kram, 2008; Raffalt et al., 2013).

The LBPP treadmill has demonstrated to have indirect effects on weight reduction by enabling exercise in individuals otherwise unable to do so. This modality is a safe way to improve $\dot{V}O_{2max}$ and also allows individuals to experience the joy in moving in a safe and pain-free environment.

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. Finally, those who are characterized as extremely obese may not fit into the shorts.

5.2 Future Recommendations

Fitness professionals should be mindful of individualizing exercise programs with regard to choosing the appropriate methods to achieve health goals when working with individuals with obesity.

The current research provides a starting point for investigating LBPP and physiological measures 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. In addition, future studies are needed to address the effects of LBPP on weight control in overweight or obese individuals for both walking and running. Furthermore, there is limited research on the physiological effects of training on a LBPP device and more studies are needed to identify optimal training protocols for weight reduction in overweight and obese individuals.

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* (9thed.). Baltimore, MD: Lippincott Williams and Wilkins.

Arborelius, M., Balldin, U. I., Lilja, B., & Lundgren, C. E. G. (1972). Hemodynamic changes in man during immersion with the head above water. *Aerospace Medicine, 43*, 592-598.

Barela, A.M., Stolf, S.F., &Duarte, M. (2006). Biomechanical characteristics of adults walking in shallow water and on land. *Journal of Electromyography Kinesiology*, *12*, 250-256.

Blair, S.N., Kohl, H.W., Paffenbarger, R.S., Clark, D.G., Cooper, K.H., & Gibbons, L.W. (1989). Physical fitness and all-cause mortality: A prospective study of healthy men and women. *Journal of the American Medical Association, 262,* 2395-2401.

Booth, F. W., Roberts, C. K., &Laye, M. J. (2012). Lack of exercise is a major cause of chronicdiseases. *Comprehensive Physiology*, *2*(2), 1143–1211. http://doi.org/10.1002/cphy.c110025

Borg, G., &Linderholm, H. (1967). Perceived exertion and pulse rate during grades exercise in various age groups. *ActaMedicaScandanavia, 187*, 17-26.

Borg, G. (1998) *Borg's perceived exertion and pain scales*. Champaign, Il: Human Kinetics.Centers for Disease Control and Prevention Physical activity for everyone(2011). http://wwwcdcgov/physicalactivity/everyone/glossary/indexhtml.

Chevutschi, A., Alberty, M., Lensel, G., Pardessus, V., &Thevenon, A. (2009). Comparison of maximal and spontaneous speeds during walking on dry land and water. *Gait Posture*, *29*(3), 403-407.

Cohen J. (1988). *Statistical power analysis for the behavioral sciences* (2nded) 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

Donnelly, J.E., Blair, S.N., Jakicic, J.M., Manore, M.M., Rankin, J.W., & Smith, Bryan, K.(2009). Appropriate physical activity intervention strategies for weight loss and prevention of weight regain for adults. *Medicine & Science in Sports & Exercise, 41*(2), 459-471. doi: 10.1249/MSS.0b013e3181949333

Faul, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, *41*, 1149-1160.

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.

Fogelholm M. (2010). Physical activity, fitness and fatness: relations to mortality, morbidity and disease risk factors. A systematic review. *Obesity Review, 11*, 202- 221.

Gaesser, G.A. (1999) Thinness and weight loss: beneficial or detrimental to longevity? *Medicine Science in Sports Exercise 31*, 1118–1128. doi: 10.1097/00005768-199908000-00007

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.

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.

Jakicic, J.M., Donnelly, J.E., Pronk, N.P. Jawad, A.F. & Jacobsen, D.J. (1995). Prescription of exercise intensity for the obese patient: The relationship between heart rate, VO2 and perceived exertion. *International Journal of Obesity Related Disorders, 19*(6), 382-387.

Kodama, S., Saito, K., Tanaka, S., Maki, M., Yachi, Y., Asumi, M., Sugawara, A., Totsuka, K., Shimano, H., Ohashi, Y., Yamada, N., & Sone, H. (2009). Cardiorespiratory fitness as a quantitative predictor of all-cause mortality and cardiovascular events in healthy men and women: a meta-analysis. *Journal of the American Medical Association, 301,*2024–2035.

Lafortuna, C.L., Agosti, F., Galli, R.,Busti, C. &Lazzer, A.S. (2008). The energetic and cardiovascular response to treadmill walking and cycle ergometer exercise in obese women. *European Journal of Applied Physiology, 103*, 707. doi:10.1007/s00421-008-0758-y

Lee, D.C., Sui, X., Ortega, F.B., Kim, Y.S., Church, T.S., et al. (2011) Comparisons of leisure-time physical activity and cardiorespiratory fitness as predictors of all-cause mortality in men and women. *British Journal of Sports Medicine45*, 504–510. doi: 10.1136/bjsm.2009.066209

Management of obesity. A national clinical guideline. Edinburgh (Scotland): Scottish Intercollegiate Guidelines Network (SIGN); 2010 Feb.

McAuley, P. A., Kokkinos, P. F., Oliveira, R. B., Emerson, B. T., & Myers, J. N. (2010). Obesity paradox and cardiorespiratory fitness in 12,417 male veterans aged 40 to 70 years. *Mayo Clinic Proceedings*, *85*(2), 115–121. http://doi.org/10.4065/mcp.2009.0562

Mougios, V., & Deligiannis, A. (1993). Effect of water temperature on performance, lactate production and heart rate at swimming of maximal and submaximal intensity. *The Journal of Sports Medicine and Physical Fitness, 33*, 27-33.

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.

Simonson, S.R., Shimon, J.M., Long, E.M., & Lester, B. (2011). Effects of a walking program using the AlterG® anti- gravity treadmill system on an extremely obese female: A case study. *Clinical Kinesiology, 65*(2)*,* 29-38.

Wen, C.P., Wai, J.P., Tsai, M.K., Yang, Y.C., Cheng, T.Y., et al. (2011) Minimum amount of physical activity for reduced mortality and extended life expectancy: a prospective cohort study. *Lancet, 378*, 1244–1253. doi: 10.1016/s0140-6736(11)60749-6

WHO. (2016). Global strategy on diet, physical activity and health. Retrieved from: http://www.who.int/dietphysicalactivity/pa/en/

Winett, R. A., &Carpinelli, R. N. (2000). Examining the validity of exercise guidelines for the prevention of morbidity and all-cause mortality. *Annals of Behavioral Medicine*, *22*(3), 237-245.

Table 1: Descriptive statistics for 14 participants

	N	Minimum	Maximum	Mean	Std. Deviation
Age (y)	14	20.00	28.00	23.50	2.42
Height (m)	14	1.63	1.87	1.75	.07
Weight (kg)	14	88.50	145.82	111.59	16.37
Bodyfat(%)	14	25.50	44.00	37.02	6.19
BMI (kg/m^2)	14	30.9	44.10	36.51	3.82
Waist (cm)	14	88.9	125.00	104.30	9.73
HR_{max}(bpm)	14	192.0	200.00	196.86	2.44
HR_{85} (bpm)	14	163.0	170.00	167.25	2.00
Valid N	14				

Table 2: Mean ± SD values for peak HR, RPE and VO_2.

	100% BW	75% BW	*p*
HR (bpm)	157 ± 2	141 ± 2	0.010*
RPE (6-20)	14 ± 1	12 ± 2	0.013*
$\dot{V}O_2$(ml/kg/min)	23 ± 4	17 ± 3	0.002*

Values are means ± SD. HR, heart rate; RPE, rate of perceived exertion; $\dot{V}O_2$, oxygen consumption. *p< 0.05, 100% BW compared to 75% BW.

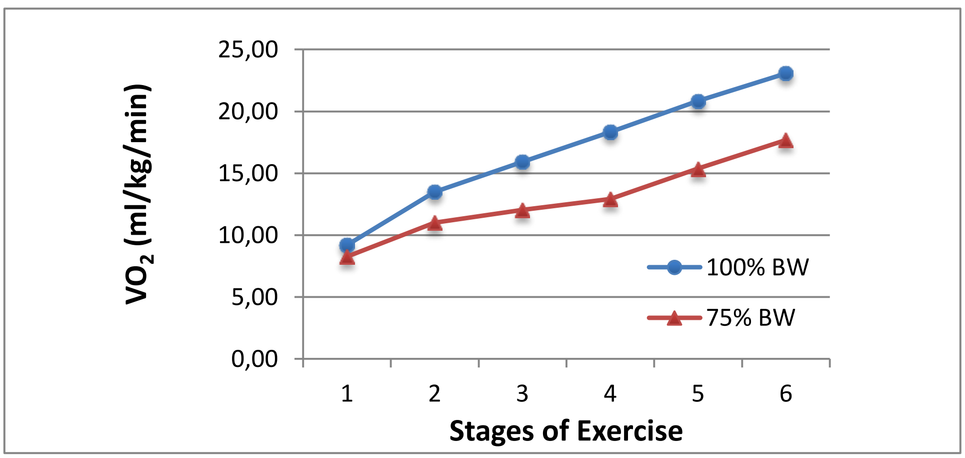

Figure 1: **Oxygen consumption ($\dot{V}O_2$) measured during each three-minute stage of exercise on the AlterG® at 100% BW and 75% BW. Graphic shows that as exercise intensity increases $\dot{V}O_2$ increases.**

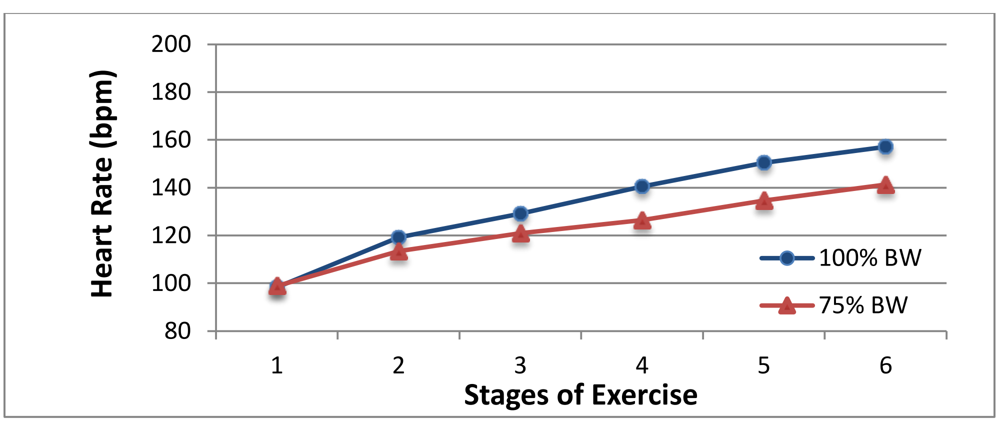

Figure 2: **Heart rates expressed in beats per min (bpm) measured on the AlterG® at 100% BW compared to 75% BW. Graphic shows that as exercise intensity increases heart rate increases**

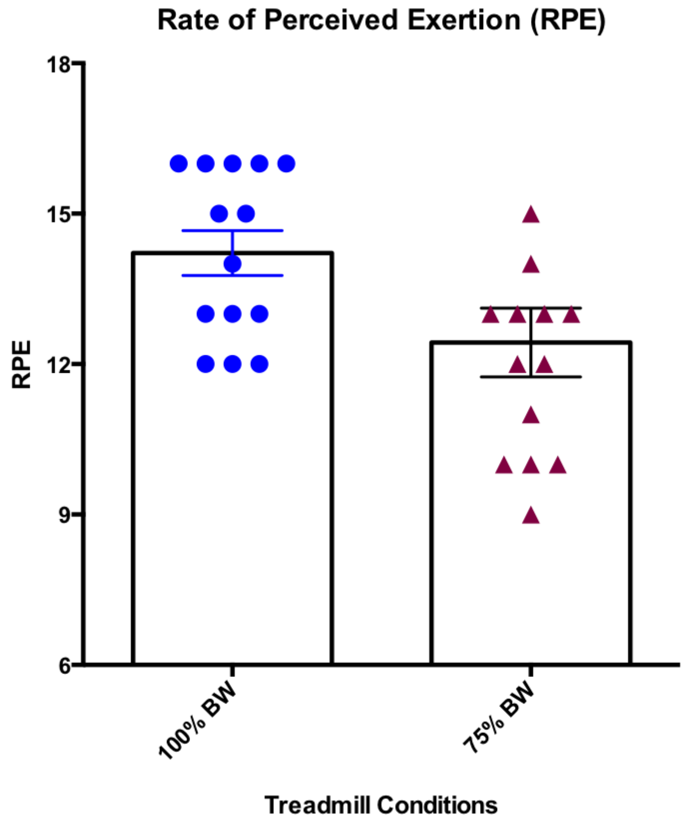

Figure 3: **Rate of perceived exertion measured on the AlterG® at 100% BW and 75% BW. Graphic shows that perceived exertion decreases as body weight is reduced.**