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The Effects of Walking on the Alter-G® Treadmill on Fat Oxidation in Overweight/Obese Males

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THE EFFECTS OF WALKING ON THE ALTER-G® TREADMILL ON
FAT OXIDATION IN OVERWEIGHT/OBESE MALES

BY

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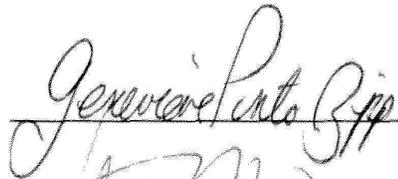
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This journey is over but a new beginning is waiting!

It is good to have an end to journey towards….

But, it is the journey that matters, in the end. …..

~ Ursula K LeGuin, novelist ~

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ABSTRACT

THE EFFECTS OF WALKING ON THE ALTERG® TREADMILL ON FAT OXIDATION IN OVERWEIGHT/OBESE MALES

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Purpose: To determine if a reduction of body weight from 100% to 75% while walking on a lower body positive pressure treadmill (LBPP) affects peak oxygen consumption ($\dot{V}O_{2peak}$), fat oxidation (FO), peak fat oxidation (PFO), respiratory exchange ratio (RER), heart rate (HR) and rate of perceived exertion (RPE) in overweight and or obese men. **Methods:** Fourteen, overweight and obese men (mean age 23.2 ± 2.4 years, BMI 36.5 ± 3.8 kg/m^2 and Body Fat % 38.6 ± 7.0%) were randomly assigned to walking on the LBPP treadmill at 100% and 75% of their body weight. The protocol consisted 3-minute stages at a constant speed of 3.3 mph for the duration of the test. Percent grade increased three minutes following the warm up from 3% to a maximum of 15%. FO, PFO, RER and $\dot{V}O_2$ were measured using indirect calorimetry. Fat oxidation rates were calculated using stoichiometric equations. **Results:** Significant differences in $\dot{V}O_{2peak}$, fat oxidation rates, HR and RER ($p < .05$) were identified using a paired samples t-test, between the treadmill conditions (100% BW and 75% BW).

$\dot{V}O_{2peak}$ and HR were higher at 100% BW compared to 75% BW (23 ± 4 vs.

17 ± 3 ml/kg/min, and 157 ± 23 vs. 141 ± 20, respectively). Additionally fat

oxidation rates were lower at 100% BW compared to 75% BW (-0.19 g/min

vs. 0.04 g/min). PFO occurred at 40% of $\dot{V}O_{2peak}$ (0.22 g/min at 9.21

ml/kg/min) in the 100% BW condition where PFO occurred at 47% to 62% of

$\dot{V}O_{2peak}$ (0.23 g/min at 17.69 ml/kg/min and 0.23 g/min at 17.69 ml/kg/min

respectively) in the 75% BW condition. RPE was significantly lower at 75%

BW compared to the 100% body weight condition (12 vs. 14, respectively).

FO rates in the decreased BW condition were observed at a low to moderate

intensity (40 to 62% $\dot{V}O_{2peak}$) which also stayed elevated longer compared to

100% BW. **Conclusion:** Reducing one's body weight on the LBPP can be

used as a low to moderate intensity exercise for obese individuals as a

means to sustain physical activity, improve one's exercise tolerance resulting

in an improved quality of life.

Keywords: lower body positive pressure treadmill, fat oxidation, maximal

oxygen consumption, obesity

Chapter I

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, 2012). 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. 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, 2012). Obesity does not discriminate and is threatening the health of people of all ages, ethnicities and socioeconomic backgrounds across the United States.

Of great concern is the lack of consensus in the definition and specific percentage of body fat associated with obesity. However, obesity is generally thought of as an excess accumulation of stored fat (WHO, 2012). In addition, the CDC (2012) suggests that overweight and obesity are labels for a range of weight that is greater than what is considered healthy for a given height also known as Body Mass Index (BMI). BMI is measured by a person's weight in kilograms (kg) divided by height in meters squared (m^2). Overweight is defined as a BMI of $> 25 – 29.9$ kg/m^2 and obesity as a BMI $\geq$

30 kg/m^2. The American College of Sports Medicine (2012) states that the

composition of body weight is more important than BMI as it reveals relative

proportions of fat and lean body mass. Specifically above 22% body fat for

men and above 32% body fat for women is considered a health risk. Body fat

is measured by skinfold measurements of subcutaneous fat or body density

determined from weighing an individual underwater.

It is well established that obesity or excess body fat, is associated with

an increased risk of multiple chronic and metabolic diseases, as well as

orthopedic and psychosocial problems, which frequently result in an increase

in healthcare costs (CDC, 2012). Thus one's pattern of fat distribution can be

an important indicator of one's health and prognosis. Specifically, individuals

with an overabundance of abdominal fat are at higher risk for metabolic

syndrome, which is characterized by a cluster of risk factors, more so than

those who have fat distributed in the hip and thigh area. Interestingly, the

cluster of those risk factors include, hypertension, insulin resistance,

overweight/obesity, elevated triglycerides, small low density lipoproteins

(LDL) cholesterol particles, reduced high density lipoproteins (HDL)

cholesterol, increased risk of thrombus formation, elevated C-reactive protein,

type 2 diabetes and cardiovascular disease all which can lead to premature

death. While not one of the cluster factors, those who have an excess of

visceral fat (accumulated around the organs) are also at a high risk for

developing metabolic syndrome compared to someone who possesses that

fat subcutaneously (just under the skin) (NCEP, 2004).

The etiology of overweight and obesity is complex, as many factors are involved in weight regulation. Historically, obesity has been viewed as an imbalance of energy intake (food consumption), energy expenditure (physical activity) and energy storage (Hill, 2006). Treatment and management of obesity has typically sought to modify energy intake and energy expenditure in order to yield a negative energy balance. 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 ($\dot{V}O_{2max}$) (NHLBI, 2012; NIH, 2012; WHO, 2010 & Wing, 1999; ACSM, 2012).

Mechanisms that trigger some of the favorable outcomes of exercise in obese individuals are the effect of exercise training on substrate utilization, which is how the body burns fats and carbohydrates to fuel a muscle contraction. Individuals who are obese and/or have type 2 diabetes, have an impaired ability to utilize fat as a fuel during exercise (Blaak & Saris, 2002; Jeukendrup & Wallis, 2005; Achten & Jeudendrup, 2004). Stored in adipose (fat) tissue, triglycerides are the major source of energy derived from fat which then become available as free fatty acids (FFA). During exercise of long duration it is necessary to maintain adequate levels of circulating FFA to provide energy (Kanaley et al., 2001) and given that obese individuals

possess greater fat stores, exercise may be an ideal impetus to mobilize and oxidize fats (Philllips et al., 1996). However in obese individuals impairments occur in their ability for the skeletal muscle to utilize free fatty acids (FFA) during exercise, as well as after weight loss (Blaak & Saris, 2002; Achten & Jeudendrup, 2004). Conversely, increased levels of fat oxidation can spare the use of muscle glycogen during exercise and contribute to fat loss (Brooks, 1987; Romijn et al, 1993). The literature supports that the ability to utilize fat during exercise in normal weight individuals (Phillips et al., 1996; Friedlander et al., 1998) and in obese populations (van Aggel-Leijssen et al., 2002) is increased following endurance exercise training. Therefore, exercise interventions to increase FFA oxidation in overweight and obese individuals are important in weight management and may have the potential to reduce health risks and may have important clinical relevance (van Aggel-Leijssen et al., 2001, Achten & Jeudendrup, 2004).

Although regular physical activity as a tool for management of overweight and obese individuals have proven health benefits, modes such as walking and running present, for many, a challenge due to the additional weight loads on the joints in the lower extremities, which frequently creates stress and results in secondary injuries (Browning et al. 2007).   Weight bearing exercise with an excess of body weight may increase the potential for injury or exacerbate existing joint conditions and may further influence one's ability to exercise. Based upon the possible negative outcomes associated

with many weight-bearing exercises, further investigation of available non-weight bearing exercise is warranted.

The American College of Sports Medicine (ACSM, 2012) recommends low to moderate intensity (40% to 65% $\dot{V}O_{2max}$), long duration exercises (> 30 minutes) for individuals who are overweight and obese. Additionally, low intensity and longer duration exercise options would be recommended for those who are deconditioned and carry excessive weight and who may not be able to participate in high intensity exercise. Optimizing exercise participation for obese individuals could include modalities that are non-weight bearing to minimize injury and induce increased fat oxidation, which reduce body weight and improve health outcomes.

In light of the ACSM requirement, a variety of non-weight bearing low impact exercise devices and protocols have emerged on the market and in the literature, including aquatic exercise, which has been shown to reduce stress on the joints and improve aerobic capacity (Greene et al., 2009). Using the foundational premise of aquatic exercises matched with the externally paced treadmill training protocols, aquatic treadmill training has emerged as a tool of choice for many. The aquatic treadmill (ATM) used for exercise training and rehabilitation, reduces the vertical component of the ground reaction forces (GRF) compared to land exercise, ultimately reducing stress on the lower extremities and thus reducing potential injuries (Nakazawa, Yano, & Miyashita, 1994). However, several limitations associated with aquatic

exercise including the drag forces which cause changes in walking speed, gait timing, joint kinematics, joint kinetics and muscle activity compared to over-ground walking have been noted (Chevutschi et al., 2009; Barela et al., 2006).

Over the last several years the use of partial body weight support treadmill training (PBWSTT) devices have emerged as the tool of choice. These devices have been used as training protocols for neurological and orthopedic rehabilitation to assist in upright ambulation by reducing biomechanical risks by decreasing ground reaction forces (GRF's) in specific populations (American Physiological Society, 2005). Training on a PBWSTT device, requires the individual to wear a modified climbing harness around the waist and pelvis, which is attached to a weight suspension apparatus where a constant upward force on the body is applied. However, this device can be cumbersome and uncomfortable and can inhibit circulation in extended rehabilitation and training sessions (Griffin et al., 1999; Grabowski et al., 2005).

More recently, a lower pressure positive pressure device (LBPP), the AlterG® anti-gravity treadmill, developed by NASA is currently being used in rehabilitation of lower extremity injuries, spinal cord, and stroke. The AlterG® contains an airtight chamber where a subject zippers the aperture attached to the treadmill to a pair of neoprene shorts with a kayak-style spray skirt at the waist. Once zippered in, an airtight seal is created from the subject's waist to

the feet and a small increase in air pressure applies a lifting force to the subject's lower body allowing for the manipulation of unweighting up to 80% of an individual's body weight. The AlterG® eliminates the drag forces of the legs, allowing for similar gait patterns to normal weight land walking, does not impede circulation and is more comfortable, adjustable and can be used for extended periods of time (Grabowski, 2010). Recent investigations demonstrate favorable changes in physical activity levels, exercise tolerance with similar results in cardiorespiratory 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.

Purpose of the Study

The purpose of this study was to compare the effects of walking on the AlterG® anti-gravity treadmill at 100% body weight compared to 75% body weight on fat oxidation (FO), peak fat oxidation (PFO), peak oxygen consumption ($\dot{V}O_{2peak}$), respiratory exchange ratio (RER), rate of perceived exertion (RPE), and heart rate (HR) in overweight and obese men. From this investigation, the most appropriate modality to enhance fat oxidation based on ACSM's recommendations in a population of overweight and obese men may be determined.

It is hypothesized that:

H_1: There will be a statistically significant difference in Fat Oxidation (FO) between the AlterG® at 100% and 75% body weight.

H_2: There will be a statistically significant difference in Peak Fat Oxidation (PFO) between the AlterG® at 100% and 75% body weight.

H_3: There will be a statistically significant difference in Peak Oxygen Consumption ($\dot{V}O_{2peak}$) rates between the AlterG® at 100% and 75% body weight.

H_4: There will be statistically significant differences in Rate of Perceived Exertion (RPE) between the AlterG® at 100% and 75% body weight.

H_5: There will be statistically significant differences in Respiratory Exchange Ratio (RER) between the AlterG® at 100% and 75% body weight.

H_6: There will be statistically significant differences in Heart Rate (HR) between the AlterG® at 100% and 75% body weight.

Chapter II

REVIEW OF LITERATURE

Substrate Utilization

Carbohydrate (CHO) and fats are nutrients in the food we eat that provide the body with energy. Adenosine triphosphate (ATP) is a high-energy compound that stores energy to be used as needed. Two primary sources of energy that the body needs during rest and exercise are from CHO and fat (Wilmore & Costill, 2004). Fat provides the body with energy through a complex energy system called cellular respiration or oxidation. During prolonged, low intense exercise, fat is the predominant energy source. Fat stored inside the muscle fibers and fat cells can supply between 70,000 to 75,000 kcal of energy. CHO provides energy via the oxidative and anaerobic pathway during exercise of high intensity and short duration. CHOs are broken down as blood glucose as well as muscle and liver glycogen, which provides between 1,500 and 2,500 kcal of energy. An individual's level of physical fitness, the type, intensity and duration of physical activity, as well as body composition and hormonal status determine the compositions of the fuels that are oxidized during exercise (Jeukendrup, 2003).

The balance of carbohydrate and lipid utilization during exercise was summarized by a physiological theory of exercise called the "crossover concept" (Brooks & Mercier, 1994). This concept implies that the

predominant fuel source oxidized in an individual at rest and low exercise intensities are lipids, and at higher intensities, the predominant fuel source oxidized is carbohydrates. The crossover point (approximately 50% $\dot{V}O_{2peak}$) indicates that as exercise intensity increases, there is a shift from fat utilization to carbohydrate utilization where carbohydrates eventually becomes the predominant fuel at >70% $\dot{V}O_{2peak}$ (Brun et al., 2012). The crossover point is also dependent upon the effects of exercise intensity, nutritional status, gender, age, over training and previous exercise experience. Therefore the ability to oxidize lipids may be the basis for targeted training in those with impaired metabolic fitness.

Fat Oxidation during Exercise

Triglycerides (TG) are the major energy sources stored in fat cell and within skeletal muscle fibers. In order to be used for energy, they must be broken down to one molecule of glycerol and three molecules of free fatty acids (FFA) by a process called lipolysis (Wilmore & Costill, 2004). Insulin and catecholamines are the most important regulators of lipolysis where insulin promotes fat storage by down regulating adipose triglyceride lipase levels and inhibits hormone sensitive lipase levels (HSL) (Rabinowitz & Zierler, 1962). Catecholamines on the other hand promote lipolysis by activiating HSL (Fessler, 1965). FFAs released from adipose tissue enters the blood and eventually are diffused into muscle fibers where they are catabolized by the mitochondria by a process called β-oxidation resulting in

the formation of acetyl CoA that then enters the Krebs cycle. The combustion of the FFA molecule sends more electrons into the electron transport chain generating more energy to the exercising muscle than glucose metabolism (Spriet, 2002). Although fat provides more energy per gram than CHO, more oxygen is required for fat oxidation than CHO oxidation (Wilmore & Costill, 2004). At rest the body requires a minimal amount of oxygen, however as exercise intensity increases, energy demand increases, as does the rate of oxidative ATP. To keep up with the demand for additional oxygen, the rate and depth of breathing increases which improves the gas exchange in the lungs allowing for the heart to beat quicker to provide more oxygenated blood to the working muscles (Wilmore & Costill, 2004). Therefore, measuring the amount of oxygen consumed by the lungs can make an accurate estimate of aerobic energy production.

Measurement of Energy Expenditure and Substrate Utilization

Understanding the mechanisms underlying how to regulate body weight is important for exercise prescription and consequently health outcomes. Energy expenditure (EE) and percentage of substrates utilized during exercise and recovery are both important for weight control (Thompson et al., 1998) and have important implications for targeted exercise programs. Energy expenditure and substrate utilization at rest and during exercise are commonly measured by a method called indirect calorimetry (Wilmore & Costill, 2004).

At the turn of the 20th century, indirect calorimetry was used to determine energy expenditure in animals (Atwater & Benedict, 1905) to quantify carbohydrate and fat contributions to energy expenditure. To measure the contribution of different substrates during rest and exercise, Kroh and Lindhard (1920), found that exercise intensity, exercise duration and nutritional intake in the days before the measurement are important factors that influence the contribution of substrates utilized. Furthermore, changes in exercise intensity and duration that effect substrate utilization were confirmed in a follow-up study conducted by Edward, Margaria and Dill (1934).

To estimate the amount of energy expended it is important to know the whether carbohydrates, fats or proteins are being oxidized (Wilmore & Costill, 2004). Given that glucose and fat metabolism are influenced by the availability of oxygen (O_2) inhaled and carbon dioxide (CO_2) exhaled, calorie expenditure can be estimated by measuring these respiratory gases (Wilmore & Costill, 2004, Simonson & DeFronzo, 1990). Gas exchange, originally measured by the Douglas bag method, involves collection of expired air into large canvas bags (Douglas Bags). A small sample of the expired air is then drawn from the bag for the analysis of O_2 and CO_2. This method is currently the "gold standard" for gas exchange measurements where all other methods are validated (Carter & Jeukendrup, 2002).

The ratio between the amount of CO_2 released ($\dot{V}CO_2$) and O_2 consumed ($\dot{V}O_2$) in one breath is termed the respiratory exchange ratio

(RER). The RER can be used for estimating the respiratory quotient (RQ), an indicator of which fuel (CHO) or fat) is being metabolized to supply the body with energy. When oxidized, CHO, fat and protein differ in their chemical composition and in the amounts of O_2 utilized and CO_2 produced. Under different conditions, it is possible to obtain measures of the substrate being oxidized utilizing stoichiometric equations. Calculations of energy expenditure assume negligible contribution of protein oxidation. Protein's energy requirement is not as easily determined compared to CHO and fat as it contains nitrogen and is best measured by the amount of nitrogen eliminated in the urine. Therefore RER is generally referred to as the non-protein respiratory exchange ratio. An RER of 1.00 indicates CHO are the primary fuel being oxidized, 0.71 indicates fat is the primary substrate, and 0.85 is assumed to be an approximate 50/50 mix of both CHO and fats (ACSM, 2012; Wilmore & Costill, 2004).

Stoichiometric equations have been reported in the literature (Lusk, 1924; Brouwer, 1957; Frayn, 1983; Ferrannini, 1988; Peronnet & Massicotte, 1991) for calculating CHO and fat oxidation in g/min. Large differences in calculated CHO oxidation rates vary up to 6% as most stoichiometric equations were based on resting conditions and used glucose as the CHO. This method is questionable for estimating substrate oxidation rates, since glycogen not plasma glucose, is typically the predominant fuel used during exercise of moderate to high intensity (Romijn, Coyle, Hibbert, Wolfe, 1992;

Romijn, et al, 1993, van Loon et al, 2001). Changes in the size of the bicarbonate pool at higher intensities may invalidate the calculation of the CHO and fat oxidation (Jeukendrup & Wallis, 2005) where stoichiometry of glycogen has shown to be approximately 10% lower when compared to that of glucose (Ferrannini, 1988). New equations have been proposed based on the contribution of glucose and muscle glycogen (Jeukendrup & Wallis, 2005). In contrast, stoichiometric equations for calculating fat oxidation rates demonstrate a variability of approximately 3% (Lusk, 1924; Brouwer, 1957; Frayn, 1983; Ferrannini, 1988; Peronnet & Massicotte, 1991). Due to the type and a wide range of fatty acid chains, which are dependent on the human diet, the equations can be slightly different.

By predicting the composition of substrates oxidized, researchers have sought to optimize the equations. In one of the first studies, Lusk (1924) based his fat oxidation calculations on pork lard, Frayn (1983) used a triacylglycerol (triglyerceride) that replicated human adipose tissue, Ferrannini (1988) used palmitic acid, as this is the most abundant fatty acid in the human body and very similar to triacylglycerol used by Frayn (1983). To be more accurate, Peronnet and Massicotte (1991) took the weighted average of the 13 fatty acids that represent 99% of all fatty acids in the human body. These equations were based on a $\dot{V}O_2$ of 2.500 L/min and $\dot{V}CO_2$ of 2.25 L/min with an RER of 0.90.

Given the assumptions and limitations of using indirect calorimetry under different conditions, the measurement of gas exchange is very useful in measurements of substrate oxidation. Low to moderate intensity of less than 75% $\dot{V}O_{2peak}$ seems to be less of a problem compared to exercise of high intensity of greater than 75% $\dot{V}O_{2peak}$ which questions its validity. Jeukendrup and Wallis (1995) proposed two new equations for the calculation of CHO and fat oxidation in g/min (assuming negligible contribution of protein oxidation). For low intensity of 40-50% $\dot{V}O_{2peak}$ the energy from 1g of CHO is assumed to be 50% glucose and 50% glycogen, and moderate to high intensity of 50-75% of $\dot{V}O_{2peak}$ the energy from 1g of CHO is assumed to be 20% glucose and 80% glycogen.

Exercise intensity is an important regulator in carbohydrate and fat utilization (Romijn et al., 1993, Achten et al., 2002) and may have important implications for weight loss. Measuring substrate utilization using indirect calorimetry on a cycle ergometer, Romijn et al., (1993) found fat oxidation increased from 25% to 65% of $\dot{V}O_{2peak}$ and declined again at 85%. In their study, they only investigated three exercise intensities, (25%, 65% and 85% of $\dot{V}O_{2peak}$) and since the difference between intensities was large, fat oxidation rates may not be accurate. In another study (Achten et al., 2002), a protocol was developed to determine an intensity to elicit maximal fat oxidation rates with a larger number of exercise intensities and smaller increments. Their results show that peak fat oxidation rates occurred at 64%

$\dot{V}O_{2peak}$, which is in agreement with the results of Romijn et al., (1993).

Fat Oxidation (FO) in Overweight and Obese Individuals

The exercise intensity that elicits the highest fat oxidation rate has been termed $Lipox_{max}$ (Perez-Martin & Mercier, 2001), $Fatox_{max}$ (Deriaz et al., 2001; Nordby et al., 2006) or Fat_{max} (Achten et al., 2002; Jeukendrup, 2003 & Venables et al., 2005) and PFO (peak fat oxidation) (Bogdanis, et al., 2008). The "crossover concept", (Brooks & Mercier, 1994) where the balance of substrates during exercise is a function of intensity, has generated interest in developing exercise protocols and testing for the purpose of assessing this balance of substrates (Brun et al., 2013). A recent meta-analysis (Romain et al., 2012) confirms the conclusion of individual training studies that very low intensity targeting a level of maximal fat oxidation significantly decreases blood glucose, body weight, fat mass, waist circumference and total cholesterol.

Exercise training and substrate utilization is well documented in normal weight individuals (Jeukendrup et al., 1997; Kanaley et al., 2001; van Loon et al., 1999), where fat is the preferred energy source at rest and low to moderate intensity exercise of long duration (Brooks & Mercer, 1994; O'Brien et al., 1993; Romijn et al., 1993; Thompson et al., 1998). Sial et al., (1999) demonstrated that exercise training in elderly subjects increased total fat oxidation without a change in lipolysis or FFA availability. Similar data were found in obese and healthy lean subjects using a low-intensity exercise

program for only a few hours per week (Schrauwen et al., 2002; van Aggel-Leijssen et al., 2002), and might be more appropriate for (obese) insulin-resistant subjects.

A contributing factor to the etiology of obesity may be an impaired ability to utilize fat as a fuel during exercise (Blaak & Saris, 2002; Jeukendrup & Wallis, 2005, Kelly et al., 1999). Characteristics of obese individuals have demonstrated that impairments occur in the ability of skeletal muscle to utilize free fatty acids (FFA) during exercise, as well as after weight loss has been achieved in obese subjects (Blaak & Saris, 2002). Kelly et al., (1999) found that obese individuals have lower rates of post-absorptive fatty-acid oxidation, reduced oxidative enzyme capacity and lower levels of the enzyme carnitine palmitoyl transferase (CPT) in skeletal muscle.   However, it is not known whether or not these characteristics would limit how an obese individual utilizes lipids during exercise. Furthermore, the amount of lipid stored as triglyceride in obese individuals is increased in those with type 2 diabetes, (van Baak & Saris, 2002) with a decreased dependence for fat oxidation. This is associated with insulin resistance and type 2 diabetes (Kelly et al., 1999) and is also a risk factor for weight gain as well as weight regain after weight loss.

Exercise is an effective means to improve insulin sensitivity in lean, obese and diabetic individuals and when done on a regular basis can produce long-term changes within skeletal muscle (Venables & Jeukendrup, 2007).

To look at the effect of continuous exercise at an intensity that elicits maximal fat oxidation (Fat_{max}), Venables and Jeukendrup, (2007) found that a continuous, low intensity training protocol can elicit high rates of fat oxidation (44%) and can increase insulin sensitivity. Additionally, no changes were seen after a eucaloric interval training protocol at approximately 65% of $\dot{V}O_{2peak}$, which may suggest that exercising at a peak oxidation rate may be recommended in obese individuals. This is in agreement with other studies that investigated related changes in healthy (Schrauwen et al., 2002), obese men (van Aggel-Leijssen et al., 2002) and upper-body obese women (van Aggel-Leijssen et al, 2001). These studies found that an increase in non-plasma fatty acid oxidation was a direct result of the increase in total fat oxidation and not by increases in plasma fat oxidation. Although the results of the study by Venables and Jeukendrup (2007) of continuous, low intensity exercise found improvements insulin sensitivity, their results are not in agreement with other studies that found no change in insulin sensitivity during low-intensity exercise in obese individuals (Houmard et al, 2004; Kang et al., 1996), which is probably due to different protocols of higher intensities.

Obese individuals have excessive fat stores, which may be the best stimulus to mobilize and oxidize fats (Phillips, et al., 1996). With exercise of longer duration, fat stores are mobilized to provide the necessary energy (Brooks & Mercier, 1994) sparing CHO. Kanaley, et al., (2000) investigated the differences in CHO and fat oxidation rates in lean and obese women and

concluded that 30 minutes of high intensity exercise at 70% of $\dot{V}O_{2max}$

resulted in 30% higher rate of fat oxidation in the obese women compared to

the non-obese women and also indicated that circulating levels of plasma

FFA were similar in both groups. This difference may suggest that

differences between the groups are in the ability to mobilize glucose, or the

availability of glucose to the muscle cell. It has been suggested that substrate

utilization within the muscle is determined by the availability of glucose within

the cells and not FFA concentrations (Wolfe, 1998). Low intensity exercise

training at 40% of $\dot{V}O_{2peak}$, demonstrated an increase in total fat oxidation

during moderate intensity exercise in obese men, where high intensity training

at 70% of $\dot{V}O_{2peak}$ did not affect total fat oxidation (van Aggel-Liejssen et al.,

2002). This could suggest that a low intensity exercise program may be

effective in increasing fat oxidation during exercise (Blaak & Saris, 2002).

Additionally, a low intensity exercise program may be more effective in

women who are obese in the upper body compared to women who are obese

in the lower body, as relative fat oxidation was more pronounced in the

women with upper body obesity compared to those with lower body obesity

(van Aggel-Leijssen et al., 2002).

In contrast, another study conducted by Kanaley and colleagues

(1993) found that fat oxidation did not increase after a 16-week training

program in the same population as van Aggel-Liejssen, et al. (2002).

However there was an increase in CHO oxidation, which is consistent with a

12-month training study in obese men (Pasman et al., 1999) and a training study in post-obese women (Turcotte et al., 1992). The results of Turcotte et al., (1992) may be due to increased insulin sensitivity that may increase glycogen storage ultimately leading to an increase in CHO storage over 24 hours which will have an effect on exercise fat oxidation.

Although an increased capacity to oxidize fat may help to maintain fat balance at a lower fat mass in individuals with obesity (van Baak, 1999), the results are controversial and little is known regarding patterns of fuel use during exercise and obesity. There seems to be a large variation where peak fat oxidation occurs at a given intensity and has been suggested that this is a result of body composition, gender, and the type of exercise activity (Achten et al., 2003, Perez-Martin et al., 2001; Tarnopolsky, 2008). There is little information on fat oxidation and obese individuals as most of the studies have used subjects that are young with moderate to high $\dot{V}O_{2peak}$. Additionally, the majority of the studies used cycling as the type of exercise (Achten & Jeukendrup, 2003; 2004; Perez-Martin et al., 2001) where fat oxidation is approximately 30% lower on the cycle compared to walking at equivalent intensity (Achten et al., 2003). Furthermore, very few studies have looked at peak fat oxidation rates during walking (Achten et al., 2003; Venables et al., 2005; 2008). Those studies used walking speeds that were between 6.5 and 7.5 km/h, which is close to the transition of walking to running and might be too intense for overweight and obese individuals. Compared to normal weight

adults, obese adults may be more at risk of developing knee osteoarthritis (Felson, et al., 1998) walking at faster speeds, therefore walking slower may be more effective in reducing the risk of injuries in the lower body. Bogdanis et al., (2008) found that walking at a moderate speed of 5.0 to 5.5 km/h might be an appropriate intensity to elicit PFO for overweight individuals and may be an appropriate method to improve overall health in this population.

Energy Expenditure in Land-Based Treadmill Walking in Overweight and Obese Individual

Several studies have examined energy expenditure (EE) in overweight and obese subjects. Browning et al. (2005) looked at the effects of adipose tissue distribution on 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. They also concluded body mass did not explain the differences in metabolic weight between groups. Lafortuna et al. (2008) wanted to determine the most appropriate type of exercise for the obese population and compared energy expenditure (EE) and cardiovascular responses of walking on a treadmill (TM) and cycling.   They found energy requirements of treadmill (TM) walking was higher than cycling and that the TM is more convenient for the obese population. LeCheminant et al. (2009) conducted a randomized control trial

where subjects were randomly assigned to either a walking or jogging group and each participant wore a pedometer. Resting metabolic rate (RMR) was higher in overweight/obese women compared to normal weight women. The walking group demonstrated an EE that was 27% higher in overweight and obese women compared to normal weight women. The running group had an EE 31% higher in overweight/obese compared to normal weight women and there was no difference in pedometer counts between groups. These studies support other literature that body mass significantly impacts resting metabolic rate and EE during a given activity and intensity impacts EE.

Energy Expenditure in Deep Water Running (DWR), Shallow Water Running (SWR) and Underwater Treadmill Walking (UTW)

Optimal exercise prescription for overweight and obese individuals should enable EE at the same time as well as minimize the potential for injury (ACSM, 2010). 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. The buoyancy effect of water reduces impact and stress on the joints and is therefore an optimal exercise environment for overweight and obese individuals (Silvers et al., 2007).

Deep water running (DWR), a common form of aquatic running, where participants run in place or across to the deep end of a pool are equipped with a tethered pulley system and a buoyant vest (Silvers et al., 2007). Several studies have demonstrated that $\dot{V}O_2$ and heart rate (HR) are lower when

compared to land treadmill running with a wide range of results (Chu et al.,

2002; Dowzer et al., 1999; Frangolias et al., 1996; Glass et al. 1995; & Town

& Bradley, 1991). Factors that may account for the differences in $\dot{V}O_2$ and

HR are water temperature, hydrostatic pressure, self-selected stride rate,

exercise intensity, lack of ground support and unfamiliarity of the technique

(Silvers et al., 2007). Maximal oxygen consumption ($\dot{V}O_{2max}$) of shallow water

running (SWR) resembles land running where participants typically run in the

shallow end of a pool immersed about waist deep (Silvers et al., 2007). In

SWR, the force of buoyancy is lower and the push off of a hard surface is

similar to land treadmill running (Dowzer et al., 1999; Town & Bradley, 1991).

In addition GRFs are reduced due to the depth of submersion as well as

added resistance of lower-limb movements (Nakazawa et al., 1994).

Previous research that compared SWR with land running has produced mixed

results regarding cardiorespiratory responses (Dowzer et al., 1999; Gleim &

Nicholas, 1989; Pohl & McNaughton, 2003). The differences may due to the

use of different testing protocols and in the use of an underwater treadmill

versus a static pool surface for SWR.

　　　　Underwater treadmills (UTMs) are submersed in water and some have

water jets that adjust water depth and treadmill speed to control intensity

(Silvers et al., 2007). In addition, UTMs eliminate the forward locomotion that

alleviates increased frontal resistance as seen with SWR. The results of the

relationship between UTM and land treadmill running in fifteen male runners

were investigated by Dowzer et al., (1999) and found that SWR can elicit peak cardiorespiratory responses compared with land treadmill running during maximal exertion. To compare changes in body composition, loss in body weight, and cardiovascular fitness in LTM and UTW training in overweight and obese men and women, Greene et al., (2009) conducted a randomized control trial for 12 weeks.   Consistent with exercise guidelines recommended by the ACSM for general cardiovascular fitness, intensity and training volume were matched on both modalities. In addition, the UTW depth of the water was individualized to each subject's fourth intercostal space. No gender differences in training response between groups were found, however, $\dot{V}O_{2max}$ significantly increased in both groups, BMI, body weight and body fat percentage and fat mass were significantly reduced for both groups and lean body mass increased in the legs. Their results indicate that both modes of exercise equally improved aerobic fitness and body composition and UTM is an effective training tool producing comparable improvements. Therefore, the UTM is a safe alternative to traditional LTM training for overweight and obese population. Furthermore, the magnitude of GRF is related to water depth and some UTMs are capable of being adjusted to the water depth and treadmill speed, which are the main determinants of exercise intensity (Pohl & McNaughton, 2003).

In our review of literature, two studies were found which evaluated the effects 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 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 VO_2 in the current study

was lower than Gleim and Nicholas (1989), which was probably due to the

water depth and characteristics of the subjects. Both studies confirmed that

as water depth decreased VO_2 and HR significantly increased.

In a more recent study, Alkurdi et al., (2010), sought to determine how

small changes in water depth would affect EE, HR and rate of perceived

exertion (RPE) while walking on an UTM compared to LTM. Eighteen

females ranging from 21 to 70 years of age with a BMI between 21.5 to 44.9

kg/m^2 participated in the study. Minor changes in water depth (±10cm)

significantly influenced EE, HR and RPE regardless of walking speed. These

results are consistent with Gleim and Nicholas (1989) and Pohl and

McNaughton (2003). The reduction of GRFs is a major benefit for overweight

and obese individuals to reduce stress on their joints and the depth of water is

related to exercise intensity (Gleim & Nicholas, 1989; Pohl & McNaughton,

2003; Alkurdi et al., 2010). However 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). In addition, the lower

the water below the waist, the greater the metabolic cost, in contrast, when water is at waist level or higher, metabolic cost decreases (Gleim & Nicholas 1989; Pohl & McNaughton, 2003).   Finally, two factors influence energy expenditure, drag resistance and hydrostatic force supporting body weight (Alkurdi et al., 2010).

Energy Expenditure in Reduced Gravity (Harness Suspension Systems and Lower Body Positive Pressure Treadmill)

Although benefits have noted in walking program participation, the relative effort required for overweight and obese individuals may influence their participation in a walking program. Obese individuals expend more energy than normal weight individuals (Browning & Kram, 2005), and thus place them at a greater percentage of their maximum aerobic capacity, which may negatively affect the duration of their exercise session (Alkurdi et al., 2010). Over the past 10 years, lower body positive pressure (LBPP) devices have been researched as they resemble land walking and offer options for modulating the degree of body weight participants need to support. This modulation in body weight support may reduce lower extremity stress observed in of overweight and obese individuals while supporting improvements in cardiovascular health.

Studies using LBPP devices such as harness suspension systems used to support body weight during walking have demonstrated that walking requires less metabolic power (Grabowski et al., 2005, Farley & McMahon

1992; & Griffin et al., 1999).   In addition, supporting body weight has been noted to reduce biomechanical risks during walking and running. For those who are overweight, obese, in pain, rehabilitating and/or recovering from an injury, weakness or instability, unloading may be a positive exercise alternative. However, it is of concern that individuals walking at slower speeds with body weight support may experience a reduction in their cardiovascular fitness due to the low metabolic demand of the cardiorespiratory system (Grabowski, 2010).

Farley and McMahon (1992) used a harness system on runners and walkers to simulate reduced gravity, thereby reducing body weight (BW) but not body mass. They found that net metabolic cost decreased by 33% during walking at 0.25 BW at 1.0 m/s compared with walking at 1.0 m/s at normal body weight. In addition, Grabowski et al., (2005) used a slightly different harness support than Farley and McMahon (1992) to measure metabolic rate changes in normal weight men and women in simulated reduced gravity with added loads and found that net metabolic power was 21% lower at 0.25 BW while walking at 1.25 m/s compared to walking at 1.25 m/s at normal body weight. The contrasting results in metabolic power results might be due to the difference in the LBPP systems used. Farley and McMahon (1992) used an apparatus that was fixed to the ceiling, which applied a vertical force and assisted horizontal forces which may be responsible for overestimating net metabolic cost of supporting body weight in Farley's study. Grabowski et al.,

(2005) used a trolley system that moved forward and back with the subject as they walked which prevented the assistance of horizontal forces. In contrast to Farley & McMahon (1992) and Grabowski et al., (2005), Griffin et al., (1999) measured mechanical energy fluctuations about the center of mass using a harness suspension system and found that external work per stride at 1 m/s decreased at 50% BW. To possibly account for the higher metabolic cost, subjects were able to choose their walking patterns, which might be attributed to biomechanical efficiency of movement or the effective mechanical advantage of the extensor muscles. Additionally, decreases in reduced gravity increases the force needed to support body weight, thus may account for the increasing metabolic cost. Also, swinging the limbs relative to the center of mass may potentially increase metabolic cost more than once thought (Griffin, 1999). While, harness suspension systems address the independent effects of body weight support due to the vertical force imposed on the individual these systems can be uncomfortable and inhibit circulation within the individual and may not be a favorable modality for long-term use (Grabowski, 2010).

To determine the separate and combined effects of speed and weight support on ground reaction forces (GRFs) and metabolic power during running Grabowski & Kram, 2008, used a LBPP device called the G-trainer. They compared running slower at normal weight with running fast with weight support. They 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. Finally, running at

fast speeds with weight support will maintain cardiorespiratory demands

thereby reducing GRFs.

Grabowski, (2010) conducted a randomized control trial with repeated

measures and found that manipulating speed and weight using the Alter-G®

anti-gravity treadmill while walking, reduces force but maintains

cardiorespiratory demand while GRFs were lower when walking faster

compared to normal weight walking. In addition, when compared to normal

weight walking, walking faster with body weight support elicited the same

metabolic demand (Grabowski, 2010). In contrast to previous results

(Grabowski et al., 2005, Farley & McMahon 1992; & Griffin et al., 1999)

metabolic power using the LBPP device differed from studies that used

harness suspension systems. The AlterG® in Grabowski's (2010) study

yielded a net metabolic power of 45% lower than that of Farley and McMahon

(1992) at the same percent body weight and speed. The difference may be a

result of the differences in BW support systems used as well as directions of

support as the AlterG® provides vertical support with little horizontal and

lateral support (Grabowski & Kram, 2008).

Figueroa et al., (2011) investigated physiological responses to the

AlterG® anti-gravity treadmill on 5 males and 5 female subjects at 80%, 90%

and 100% of body weight during running. Although body mass accounts for a greater contribution to EE during running, their subjects expended fewer kilocalories as percent body weight decreased. However, consistent with previous studies (Aaslund & Moe-Nilssen, 2008; Grabowski & Kram, 2008; & Grabowski, 2010) a reduction in body weight support placed an equal amount of cardiovascular stress on each subject while reducing GRFs.

A case study conducted by Simonson, et al., (2011) examined the effects of a 14 - week walking program on one extremely obese female walking on the AlterG® anti-gravity treadmill. Their results showed a 2.75% decrease in body weight, a decrease in circumference measures of the upper body, a decrease in fasting blood glucose with a 10 fold increase in caloric expenditure, 3 fold increases in exercise tolerance as well as a decrease in edema in the lower extremities. Although the decrease in body weight was due to a low caloric expenditure, the findings from this case study are promising in that if the individual were to continue with this program, caloric expenditure should increase to then further reduce body weight.

More recently, Raffalt et al., (2013) studied 12 healthy male runners to determine if it was possible to obtain $\dot{V}O_{2peak}$ on an LBPP treadmill at normal body weight and if BW support affects respiratory responses, ground reaction forces and $\dot{V}O_2$ at a broad range of speeds. They found that there were no significant differences in $\dot{V}O_{2peak}$ between the two treadmills, which validate the use of the use of the LBPP treadmill at 100% body weight for obtaining

maximal aerobic capacity in well-trained individuals using an incline running protocol. However at high levels of body weight reduction it is unlikely that a true $\dot{V}O_2$ can be obtained due to the extreme speeds that are needed to compensate for the extensive reduction in body weight. One additional important finding in this study was that the time to exhaustion on the LBPP treadmill increased significantly compared to the regular treadmill. This finding indicates a lower energy cost of running, which may result in improved performance over an extended period of time. Additionally, the observed increase in $\dot{V}O_2$, HR, and ventilation as running speed increased was consistent with the findings of Grabowski and Kram (2008). The findings from this study supports that the LBPP treadmill is an optimal training modality for rehabilitation and low-impact training for athletes and may have important implications for those who are obese.

Cardiovascular safety and gait analysis using 6 men and 3 women between the ages of 22 to 55, mean body weight of 83.8 kg under LBPP conditions were examined by Cutuck, et al., (2006). Unloading at 25% and 50% were randomized with a constant walking speed of 3 mph. Peak GRFs decreased significantly as body weight (BW) decreased, HR decreased from 99 to 84 bpm at 50% BW, microvascular perfusion, oxygenation and blood flow velocity, head capillary diffusion and macrovascular circulation were all unchanged during LBPP conditions. Although the study sample was small, the results demonstrate that the AlterG® LBPP device is a modality that has

proven to be clinically safe.

Although the studies reviewed used different percentages of body weight, there were some differences in metabolic rate among the studies. Limitations in the harness suspension system due to the different systems used may have been a factor in the differences in metabolic rate. However it is unclear as to how each task contributes to the overall metabolic cost of walking. Farley and McMahon, (1992) used a system that attached to the ceiling that applied a vertical force and perhaps an overestimation of metabolic cost may have resulted from a possible aiding of horizontal forces. Griffin, et al., (1999) and Grabowski, et al., (2005) used a rolling trolley system that moved forward and back, which prevented the potential for horizontal aiding. Although both studies reported net metabolic rate decreased as body weight was reduced, there were differences in the amount of decrease in each study. In addition, results from those studies were also compared to the G-Trainer or AlterG® used by Cutuk, et al., (2006), Grabowski and Kram, (2008), Figueroa, et al., (2011) and Simonsen, et al., (2011). All are in agreement that harness systems address the independent effects of body weight support due to the vertical force imposed on the individual where the G-trainer (earlier model) and AlterG® is a lower body positive pressure device that uses differential air pressure to unweight the body. 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). In addition, it is a more reliable method where the amount of weight that is changed can be recorded in a more precise manner.

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 cardiorespiratory endurance, and may have a number of issues in the lower extremities that make exercising more difficult. Exercise training in a reduced gravity environment such as the AlterG® can be an optimal modality for overweight and obese individuals. 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 substrate utilization and energy expenditure utilizing the AlterG® in overweight and 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.

Chapter III

METHODS

Operational Definitions

1. Maximal Oxygen Consumption ($\dot{V}O_{2max}$) - the maximum rate at which the body uses oxygen. This is used as a measure of physical fitness.

2. Peak Oxygen Consumption ($\dot{V}O_{2peak}$) - highest value of $\dot{V}O_2$ obtained from an exercise test.

3. Fat Oxidation (FO) – The breakdown of Free Fatty Acids for energy.

4. Peak Fat Oxidation (Fat_{max}, Fat_{ox}, PFO) – exercise intensity where maximal fat oxidation is observed.

5. Respiratory Exchange Ratio (RER) – the ratio of CO_2 produced to O_2 consumed and indicates which fuel is being used for energy:

   ➢ Oxidation of one molecule of Carbohydrate =1

   ➢ Oxidation of one molecule of fatty acid = .71

6. Rate of Perceived Exertion (RPE) - a quantitative scale that indicates the intensity of an exercise.

7. Body Mass Index (BMI) - weight and height in kg/m^2

   ➢ Overweight - ≥ 25 - 29.9 kg/m^2

   ➢ Obese - ≥ 30 kg/m^2 (CDC, 2012)

8. Body Fat Percent– Fat Mass

    ➢ 22 % for men

    ➢ 32 % for women (ACSM, 2012)

Dependent Variables

1. Heart Rate (HR) – measured with 12 leads attached to an electrocardiogram (ECG)

2. Oxygen consumption ($\dot{V}O_2$) – measured from indirect calorimetry

3. Rate of perceived exertion (RPE) – Borg Scale of 6-20, which is a quantitative scale that indicates the intensity of exercise

4. Respiratory exchange ratio (RER) – indicates which substrate is utilized and is measured from indirect calorimetry

5. Fat Oxidation (FO) – rate (g/min) at which fat oxidation occurs during the exercise session

6. Peak Fat oxidation (PFO) – exercise intensity ($\dot{V}O_{2peak}$) where peak fat oxidation is observed and is measured from indirect calorimetry

Limitations

The following limitations have been acknowledged and considered when interpreting the results:

1. All measurement tools were calibrated prior to data collection.

2. It is assumed that participants answered all questions honestly and to the best of their ability for the PAR-Q and the informed consent.

3. It is assumed that participants followed the written and verbal pre-test instructions to the best of their ability.

Delimitations

This study has been delimited to the following:

1. Age $\geq$ 18 and $\leq$ 35 years;

2. BMI of > 25 kg/m^2 and body fat > 22%

3. Non-smokers

4. Must not be exercising on a regular basis of more than 2 days per week

5. Absence of signs and/or symptoms of musculoskeletal disorder that would interfere with performance

6. No recent medications that would alter physiological parameters (heart rate, blood pressure).

Medical or musculoskeletal issues were based on the Physical Activity Readiness Questionnaire (PAR-Q) (Appendix C), which is a standardized questionnaire to determine one's ability to participate in an exercise program (ACSM, 2012).

Instrumentation

1. Detecto Scale: to measure height and weight:

    Detecto's world-renowned USA-made eye-level mechanical weigh beam physician scales feature a heavy-duty solid stable 10.5 x 14.5 inch (27 x 37 cm) platform, a dual-reading die-cast weight beam which may be read from either side of the scale. The scale is long lasting, durable steel construction with an electrostatic powder paint finish for optimum quality. Detecto is the largest medical scale manufacturer in the United States.

2. Height: To insure reliability and accuracy, the subject was instructed to remove shoes, stand up straight with heels together and take a deep breath and hold it while looking straight out at head level. The height of the subject was measured by a vertical ruler, located on the Detecto scale, and measured in inches or centimeters (1 in = 2.54 cm).

3. Weight: The scale was calibrated prior to each weigh-in by keeping the scale completely still and then resetting the weight to zero. The type and amount of clothing was standardized to insure consistency of measurements. Men were free of their cellphones, wore shorts with nothing in pockets, and removed their jewelry and shoes. Since body weight can vary at different times of the day, every effort was be made to have pre measurements done first thing in the morning after an overnight fast of 12 hours to insure consistency of measurement.

4. Hydrostatic Weighing Tank - This technique of measuring body composition is based on Archimedes Principle and states that when the body is immersed in water, it is buoyed by its counterforce, which is equal to the weight of the water displaced. Body volume was calculated by this loss of weight in water as bone and muscle are denser in water and fat is less dense. Accurate measurement of body composition using this method is based on the cooperation of the subject (ACSM 2014).

5. Medgraphics Metabolic Analyzer (Serial # 218000277, Model # 790 705-005) - A gas exchange analyzer (metabolic cart), valid and reliable data is dependent on proper maintenance, calibration and testing procedure. Verification of calibration of the airflow or volume transducer can be performed with a calibrated 3-L syringe. Agreement in calculated volumes to within ±3% indicates adequate performance.

Prior to each testing session, the system was calibrated for measurement of flow, the analysis of oxygen and carbon dioxide and the timing of the two. The American Thoracic Society and the American College of Chest Physicians (2003) suggest regular quality assurance tests be done. This involves have a healthy member of the lab perform a constant work rate at several workloads at regular intervals as this would serve as a check of the system and the staff's procedures. Little quality assurance outcome data is available for comparison. The system was maintained and recalibrated in July of 2013. All facemasks and mouthpieces used per subject are new in a sealed package.

6. Gulick Spring loaded tape measure - A spring-loaded cloth tape measure was used because it standardizes the amount of pressure when taking circumference measurements. This decreases both inter- and intra-individual measurement error and improves test-retest reliability. To accurately measure waist circumference, the top of the hipbone or iliac crest was landmarked. If the hipbone was not found, measurement will be taken above the umbilicus but below the xiphoid process of the ribcage. The tape measure was placed evenly around the bare abdomen above the level of this bone. The subject was asked to breathe normally and not "suck in" their stomach. The tape measure was read and measurement recorded. The skin was allowed to relax

and the process was repeated. If each measurement was within a ¼ inch, the average of two measurements were recorded.

7. ECG Machine (Quinton® Q-Stress® 4.0) Serial number – QS007122-Heart rate was be recorded on the treadmill during the last minute of each stage using the R-R interval of the electrocardiogram (ECG) via quik-prep electrodes.

8. Quik-Prep patented electrodes are designed to hold up and hold on during heavy perspiration, excessive subject movement, and lead-wire tugging. The company proposes that these electrodes will produce a high-quality trace, free of dropout and baseline drift. An impedance check easily determines a high-quality trace. Skin preparation is essential for consistency of measures. Electrodes were not used on open sores, burn sites, scar tissue or on skin with abnormal conditions.

9. AlterG® anti-gravity treadmill -M320 model: Premarketing studies and technology validation prove the safety and effectiveness of the AlterG® anti-gravity treadmill. This treadmill which has been cleared by the FDA in 2008, uses differential air pressure for weight support and was conceived by Dr. Robert Whalen and Dr. Alan Hargens as they were studying biomechanics of exercise in space.

All electrical outlets were in compliance with building and manufacturer's codes. All equipment was disinfected after use with commercial grade disinfectant and throw away wipes.

Participants

Eighteen men, classified as overweight or obese (BMI > 25 kg/m^2, %body fat > 22%) (CDC, 2012; ACSM, 2012) were recruited by advertisement (Appendix A) on approved bulletin boards at William Paterson University. Participants excluded from the study included those with an inability to walk for 20 to 30 minutes, < 25 kg/m^2 and body fat < 22%, use of any medications (including over the counter) that would elevate heart rate or blood pressure and history of any known disease and orthopedic problems that may interfere with exercise.

Eighteen men were recruited for the 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 (Table 1) 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 effect resting or exercise heart rate and may effect test accuracy.

Sample Size

To obtain a power of 0.8 at alpha < 0.05, the paired samples *t*-test for two treadmill conditions was based on a priori calculation that was determined in a pilot study. A sample size of 14 subjects was required to determine FO and PFO between two treadmill conditions of the same subject, 6 subjects for heart rate, RPE and $\dot{V}O_2$ and 24 subjects for RER (G*Power Version 3.1.5). To date there are no studies that looked at PFO following anti-gravity treadmill training at 100% and 75% of body weight, thus supporting that these reference values could be established from the pilot study of 6 subjects.

Procedures

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%.

AlterG® Anti-gravity Treadmill: To support the participant's body weight, the AlterG® anti-gravity treadmill (Appendix D), created by AlterG®, Inc. (Fremont, CA) was used. The AlterG® is a body weight

support system that uses this differential air pressure in an enclosed treadmill space (aperture) and creates a lifting force from an individual's waist down. Each subject wore a pair of neoprene shorts that has a spray skirt with a zipper (Appendix D) that zips into the enclosed treadmill space (Appendix D) which created an airtight seal at the subject's waist.

Prior to the test, the subject was instructed to cross his arms across his chest and sit back into his heels. At this time the air pressure in the chamber was adjusted to apply the proper lifting force for each subject by way of a built in pressure feedback system where the treadmill indicated 'Cal' for calibrating and disappeared when done.

Protocol

The participants attended the laboratory on three sessions.

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.

Height: To insure reliability and accuracy, the subject was instructed to remove shoes, stand up straight with heels together while looking straight out at head level. The height of the subject was then recorded with the vertical ruler attached to the Detecto scale and measured in centimeters.

Weight: The Detecto scale was calibrated prior to each weigh-in by maintaining stillness of the scale and resetting the weight to zero. The subject was instructed to remove shoes, wear shorts, with empty pockets and remove all jewelry prior to standing on the scale. Since body weight can vary at different times of the day, all measurements were done in the morning after an overnight fast to insure consistency of measurement.

Waist Circumference: Measurements were taken two times with a Gulick Spring-loaded tape measure just above the umbilicus and below the xyphoid process at the narrowest part in the trunk. If each measurement was within one quarter of an inch, the averages of the two measurements were recorded.

Body Density: Body composition was determined by measuring body density using underwater weighing. The subject was instructed prior to testing to wear a tight fitting bathing suit or shorts. The temperature of the water was approximately 33 ± 3°C as density is determined based on water temperature. Subjects were instructed to enter the tank and attach a weight belt that prevents them from floating upward. After all the air was pressed out of their bathing suits and hair, the subject sat on the chair in the water. On cue the subject submerged their upper body including their head and neck then forcefully expelled as much air from the lungs as possible. The subject was instructed to hold their breath for a count of 5 to 10 seconds as their body density was recorded. With a tap on the tank the subject lifts their upper body

out of the water. The average of three weights was used to determine percent body fat according using the Siri equation: %Fat = 457/ Body Density - 414.2.

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. Subjects were familiarized with the Borg's Rate of Perceived Exertion (RPE) scale (Appendix D) (Borg & Linderholm, 1967) prior to entering the treadmill then RPE was recorded during the last 15 sec of the final minute of each stage. Following familiarization, the subject was instructed to put on the neoprene shorts then the principal investigator zipped the subject in to the treadmill aperture. Before the test, upon pressing the start button, the subject was instructed to cross his arms across his chest and sit back into his heels. At this time 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 where the treadmill indicated 'Cal' for calibrating and disappeared when done. The treadmill tests were randomized where the subject began on either the AlterG® at 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, 2012) or requests 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 PFO, $\dot{V}O_{2peak}$, RER, RPE, and HR.

Measurements

Resting blood pressure, measured with a stethoscope and Aneroid Sphygmomanometer, calibrated prior to each testing session,

were recorded in a seated position after a 5-minute rest period for both exercise sessions. Additionally, ECG recordings measured resting and exercise heart rates. Heart rate was monitored continuously to insure a steady state was achieved and to insure the participant did not exceed 85% of their maximal heart rate (220-age x .85). Peak heart rate was recorded during the last 15 seconds of each stage. Prior to the measurement, the subjects' skin was prepared prior to electrode placement to insure consistency of measured sites according to the following procedures:

- Shave body hair (if needed)

- Use alcohol to remove excess oil

- Check applicator tips and electrode contact to insure they are clean

- Before placement on the subject, each electrode was checked

- The electrode was attached by moving my finger around the electrode to smooth smoothing outward

- The lead wires were attached to the appropriately labeled electrodes as pictured and described below:

Likar 12-Lead Placement Sites

Six Chest Leads:
V1 – fourth intercostal space to the right of the sternum
V2 – fourth intercostal space to the left of the sternum
V3 – midway between V2 and V4
V4 – left clavicular line on the fourth rib
V5 – left anterior axillary line on the fifth rib
V6 – left mid-axillary line at the same level at V5
Four Limb Leads:
RA –right side infraclavicular area (just below the clavicle)
LA - left side infraclavicular area (just below the clavicle)
RL – on the same line as the RA, below the rib cage on the right side
LL – on the same line as the LA, below the rib cage on the left side

Once the protocol commenced, $\dot{V}O_2$, RER and FO were determined by open circuit spirometry (MedGraphics Ultima Series, St. Paul, MN Metabolic Cart). The volume and gas analyzers of the system were calibrated using a 3-L syringe prior to each subject test. All gasses were measured on a breath-to-breath basis. Therefore, $\dot{V}O_2$ was recorded at the completion of each three- minute stage and an average of the last two minutes for $\dot{V}CO_2$ and $\dot{V}O_2$ (ml/min) was used to calculate fat oxidation rates in g/min. Non-protein fat substrate oxidation was calculated using indirect calorimetry following the stoichiometric equations of Jeukendrup and Wallis (2005):

Total fat oxidation = 1.695 $\dot{V}O_2$ (L/min) – 1.701 $\dot{V}CO_2$ (L/min)

RER as defined by $\dot{V}CO_2/\dot{V}O_2$ was used to determine the contribution of substrates to energy metabolism during the exercise protocol.

Each participant was instructed to come to the laboratory at the same time for each testing condition to control for any diurnal effects on substrate utilization. Additionally, the relative contribution of substrates being oxidized, are influenced by the food consumed during the last mean and the timing of that meal (Jeukendrup & Wallis, 2005). Therefore, subjects were asked to refrain from eating for 12 hours prior to the testing day.

Chapter IV

RESULTS

Statistical Analysis

Differences between the two treadmill conditions (100% BW & 75% BW) for the following dependent variables: HR, $\dot{V}O_2$, RER and FO during each stage of exercise, were performed using a paired samples t–test. PFO was determined by the highest rate of fat oxidation during each condition and expressed as $\dot{V}O_2$. A Wilcoxon Signed Rank test was done to determine if there were any significant differences in RPE under the two treadmill conditions. Level of significance was set at $p < 0.05$. 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) and Graphpad Prism 6 (2014). A Kolmogorov-Smirnov & Shapiro Wilk test for normality was completed on all variables to determine homogeneity of variances.

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. The following formula was used in the calculation of Cohen's d effect size values for t-tests:

$$d = \frac{|\bar{x}_1 - \bar{x}_2|}{\sqrt{(\sigma_1^2 + \sigma_2^2)/2}}$$

where x_1 and x_2 are the means of group 1 and group 2, and σ_1^2 and σ_2^2 are the variances of group 1 and group 2. Effect sizes were classified as small (0.2), medium (0.5) and large (>0.8). Effect size for Wilcoxon Signed Rank test was calculated with the following formula (Rosenthal, 1991:19):

$r = \frac{z}{\sqrt{N}}$ where N is the total number of observations on which z is based.

Effect sizes for r were classified as small (0.1), medium (0.3) and large (>0.5) as 0.1 accounts for 1% of the variance, 0.3 accounts for 9% of the variance and 0.5 accounts for 25% of the variance. All effect size calculations for all dependent variables were analyzed in G*Power 3.1 (Faul et al., 2009).

Physical characteristics of the study participants are summarized in Table 1.

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				

Kologorov-Smirnov & Shapiro Wilk tests of homogeneity of variances were done on all dependent variables. The tests indicate no significant differences between groups, indicating normality of distributions. In order to compare difference scores between the independent variable with two levels (100% BW and 75% BW) on the AlterG$^®$ anti-gravity treadmill, a paired samples *t*-test was conducted on the following dependent variables: HR, $\dot{V}O_2$, RER and FO. A non-parametric Wilcoxon signed rank test was conducted to evaluate differences in RPE between 100% BW and 75% BW on the AlterG$^®$.

Table 2 summarizes the mean ± SD values for 14 participants on peak HR, RPE, $\dot{V}O_2$, RER and FO for each BW condition which was obtained in the last minute of the last stage.

—

Table 2.

Mean ± SD values for peak HR, RPE, V̇O$_2$, RER and FO.

	100%BW	75% BW	*p*
HR (bpm)	157 ± 2	141 ± 2	0.010*
RPE (6-20)	14 ± 1	12 ± 2	0.013*
V̇O$_2$ (ml/kg/min)	23 ± 4	17 ± 3	0.002*
RER	1 ± 0.1	0.97 ± 0.12	0.048*
FO (g/min)	0.23 ± 0.4	0.03 ± 0.4	0.004*

Values are means ± SD. HR, heart rate; RPE, rate of perceived exertion; V̇O$_2$, oxygen consumption; RER, respiratory exchange ratio; FO, fat oxidation.
*$p < 0.05$, 100% BW compared to 75% BW.

Heart Rate

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 an **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).
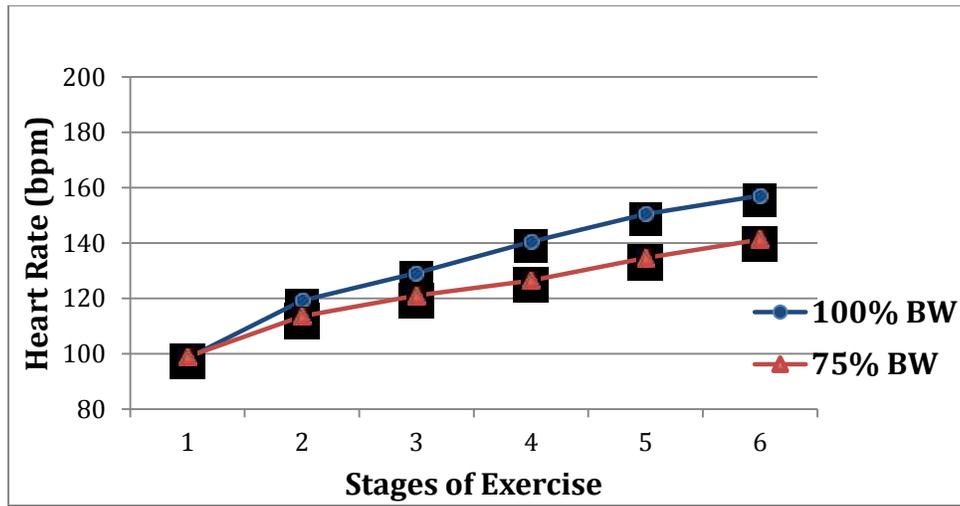
Figure 1. Heart rates expressed in beats per min (bpm) measured on the AlterG® at 100% BW compared to 75% BW. Graphic shows that as exercise intensity increases heart rate increases.

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.
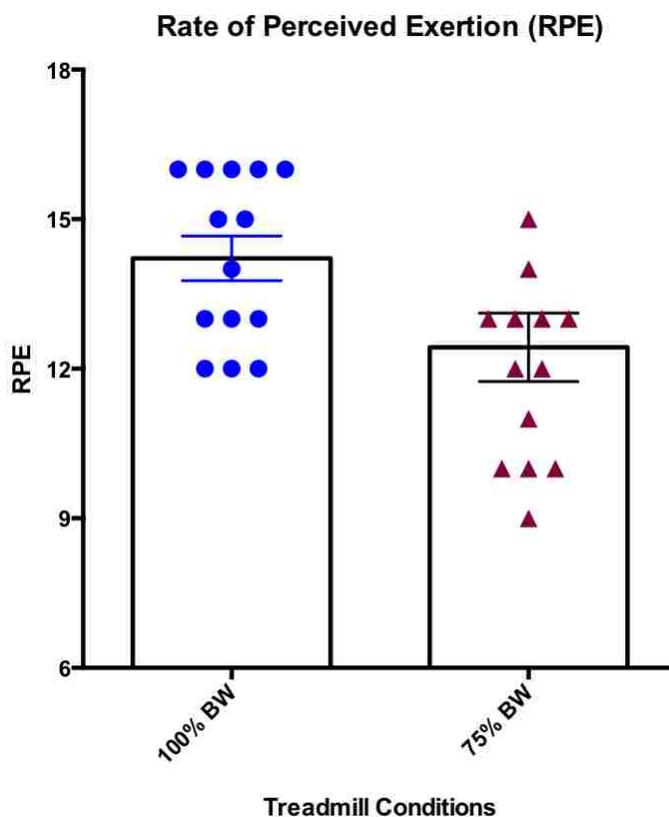
Figure 2. Rate of perceived exertion measured on the AlterG® at 100% BW and 75% BW. Graphic shows that as perceived exertion decreases as body weight is reduced.

Peak Oxygen Consumption ($\dot{V}O_{2peak}$)

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 $\dot{V}O_{2peak}$ between the 100% BW and 75% BW condition were statistically significant, (*t*(13) = 3.97, *p* <.01)*, 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). A power analysis at an **α** level of .01 based on the effect size of 1.06 revealed the probability of finding a difference 81% of the time between the two treadmill conditions. Figure 3 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).
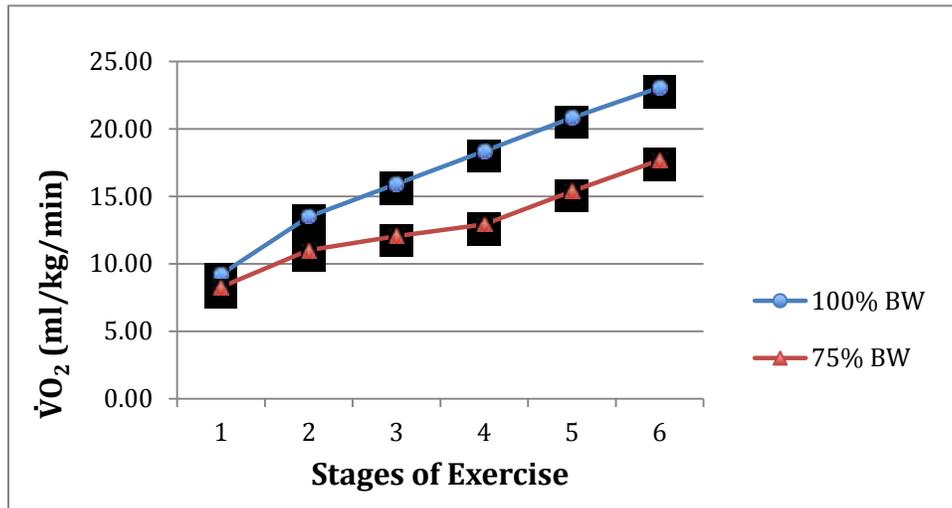
Figure 3. Oxygen consumption ($\dot{V}O_2$) measured during each three minute stage of exercise on the AlterG® at 100% BW and 75% BW. Graphic shows that as exercise intensity increases $\dot{V}O_2$ increases.

Fat Oxidation (FO) and Peak Fat Oxidation (PFO)

As exercised intensity increased fat oxidation rates decreased from

0.23 g/min to below 0 for the 100% BW and .23 g/min to 0.03 at 75% BW.

Fat oxidation at 0 or below represents an RER of 1 or higher, indicating 100%

reliance on CHO. A paired samples *t*-test showed a difference in FO rates

between the 100% BW condition and the 75% BW condition were statistically

significant, (t(13) = -3.56, p <.05)*, 95% CI [-.37, -.09], d*= .95. The effect size

of .95 was a high effect size according to Cohen's (1988) convention for a

medium effect (*d*=.50). A power analysis with an **α** level of .05 and a large

effect size of .95 revealed the probability of finding a difference 91% of the

time between the two treadmill conditions. Figure 4 shows the difference

between the two treadmill conditions where participants in the 100% BW

group had lower fat oxidation rates (*M* = -0.19, *SD* = .40) than the 75% BW

group (*M*= .04, *SD* = .40). Furthermore, fat oxidation rates peaked at 40% of

$\dot{V}O_{2peak}$ (0.22 g/min at 9.21 ml/kg/min, respectively) in the 100% BW condition

where fat oxidation rates peaked at 47 to 62% of $\dot{V}O_{2peak}$ (0.23 g/min, 0.23

g/min at 17.69 ml/kg/min) in the 75% BW condition (Figure 5).
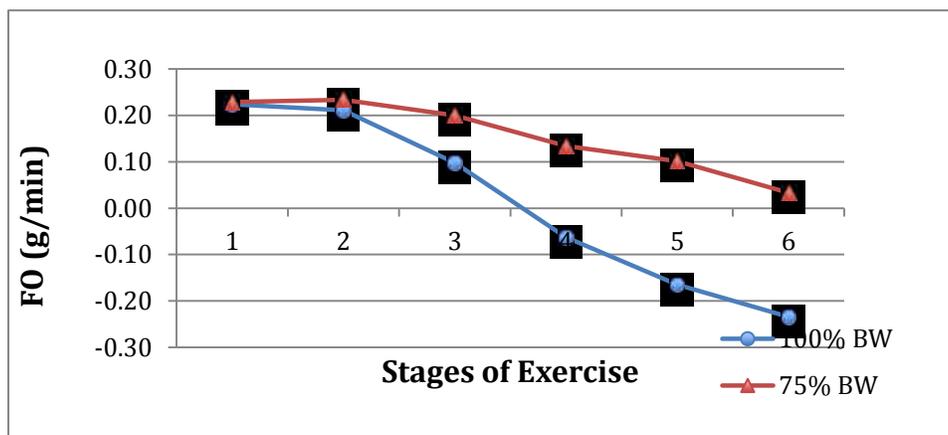
Figure 4. Graphic shows the rate of fat oxidation (g/min) at 100% BW and 75% BW as exercise intensity increases every three minutes.
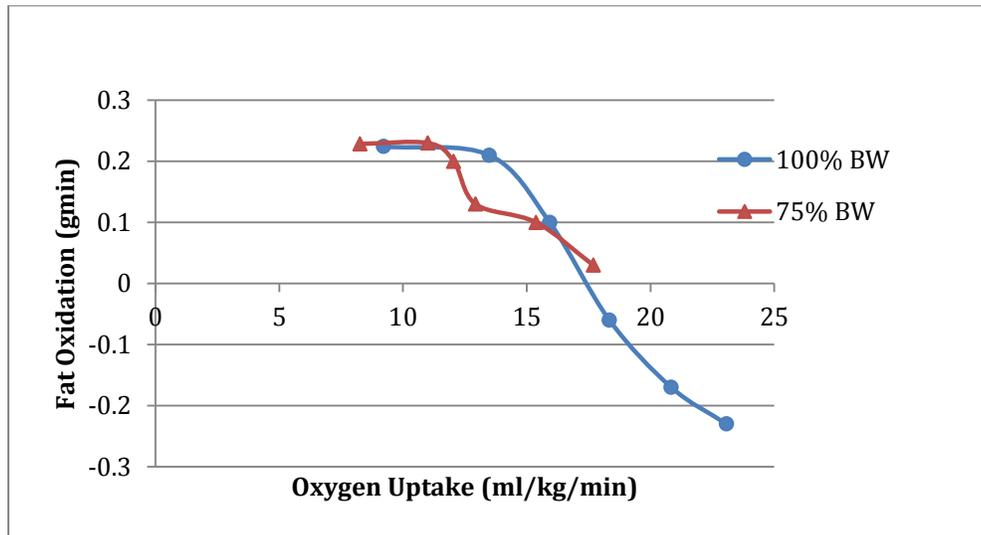
Figure 5. Graphic shows rates of peak fat oxidation relative to oxygen uptake for every three minutes of exercise.

Respiratory Exchange Ratio (RER)

There was a significant reduction in the RER from the 100% BW condition to the 75% BW condition. This means there was a significant reduction in fat oxidation rates during the exercise session. A paired samples *t*-test showed a difference in RER values averaged over the last minute of each stage between the 100% BW condition and the 75% BW condition were statistically significant, (*t*(13)= 2.18, *p* < .05)*, 95% CI [0.001, 0.13], d*= .57. The effect size of .57 was a medium effect according to Cohen's (1988) convention for a medium effect (*d* =.50). A power analysis with an **α** level of .05 with a large effect size of .95 revealed the probability of finding a difference 55% of the time between the two treadmill conditions. Figure 6 shows the difference between the two treadmill conditions where participants

in the 100% BW group had higher RER's (*M* = 1.03, *SD* = .11) than the 75% BW group (*M*= .97, *SD* = .12). Furthermore, at 100% BW, PFO occurred in the first 3 minutes of exercise at an RER of .85 indicating a 49.3% contribution of fat where PFO occurred in the first 6 minutes of exercise at an RER of .86 to .87 at 75% BW indicating a contribution of 45.9% decreasing to 42.5% of fat.
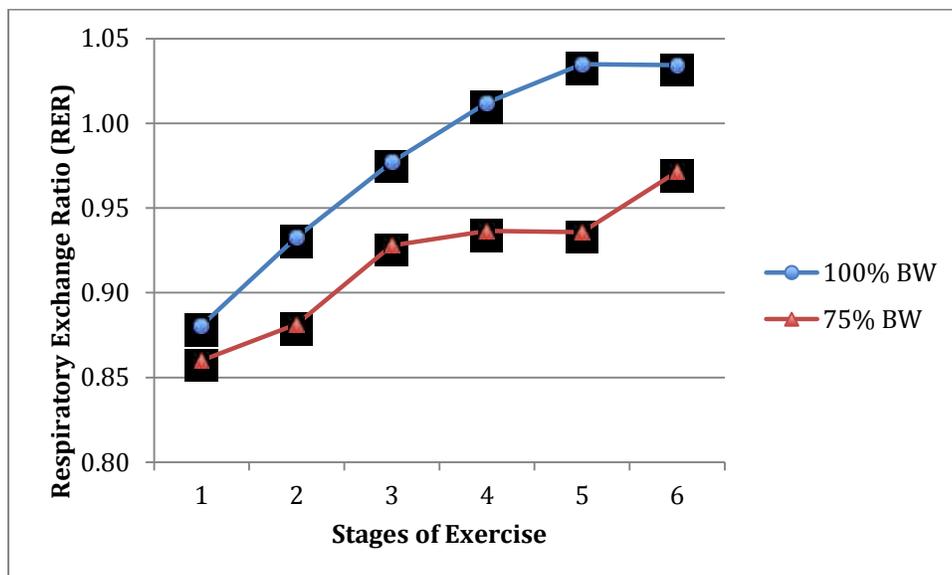
Figure 6. Respiratory exchange ratio (RER) measured on the AlterG® at 100% BW and 75% BW at each three-minute stage of exercise.

Chapter V

DISCUSSION

The purpose of the present study was to determine the differences between walking at 100% BW and 75% BW and changes in HR, $\dot{V}O_2$, RPE, FO, PFO and RER. The primary findings indicate there were significant differences in all dependent variables when walking on the AlterG$^{®}$ anti-gravity treadmill at 100% BW compared to 75% BW. The main finding of this study was that fat oxidation rates in the decreased BW condition, was observed at a low to moderate intensity (40 to 62% $\dot{V}O_{2peak}$). Another important finding was that fat oxidation rates are higher and stay elevated longer during the 75% BW condition compared with the 100% BW condition.

Exercise intensity is one of the most important factors that determine fat oxidation rates during exercise. Exercise intensity in most studies is expressed as a percentage of $\dot{V}O_{2max}$. In a study done on fat oxidation rates over a wide range of intensities, maximal rates fat oxidation ranged from approximately 47 to 52% $\dot{V}O_{2max}$ in the general population (Achten & Jeukendrup, 2004). Bogdanis et al., (2005) reported that in overweight sedentary men and women maximal fat oxidation was observed at a low intensity (50 % and 40% respectively). Furthermore, Fat_{max} has also been found at low to moderate intensities that range from 33 to 65% of $\dot{V}O_{2\ max}$ (Romijn et al., 1993; Friedlander et al., 1998; & van Loon et al., 2001;

Venables, Achten & Jeudendrup, 2005). Optimal intensity for fat oxidation is approximately 50% of $\dot{V}O_{2max}$ for untrained individual (Achten & Jeukendrup, 2004; Jeukendrup & Wallis, 2005) where activities of intensities higher than maximal fat oxidation have shown that fat oxidation rates decrease markedly (Achten et al., 2002). Peak fat oxidation rates in the current study occured at 40% of the subjects $\dot{V}O_{2peak}$ (0.22 g/min at 9.21 ml/kg/min, respectively) which occurred in the first three minutes of the exercise session at 100% BW then decreased dramatically where > 69% did not affect total fat oxidation.   In the 75% BW condition fat oxidation rates peaked at 46 to 62% of the subjects $\dot{V}O_{2peak}$ (0.23 g/min at 17.69 ml/kg/min) and occurred in the first 6 minutes of the exercise session. Not consistent with other studies, fat oxidation rates, although decreased as exercise intensity increased, did not become negligible for the duration of the test. However, peak fat oxidation rates in the current study at 75% BW (46% to 62% of $\dot{V}O_{2peak}$) are consistent with other studies done on fat oxidation (33% to 65% $\dot{V}O_{2peak}$) (O'Deriaz et al. 2001; Bogdanis et al. 2001; Romijn et al., 1993; Friedlander et al., 1998; & van Loon et al., 2001; Venables, Achten & Jeujssen, 2005; van Aggel-Liejssen et al., 2002). This is an exercise range that is considered moderate in intensity, one which is currently suggested by the American College of Sports Medicine for those interested in weight control and cardiovascular health (ACSM, 2012).

Furthermore, according to van Aggel-Liejssen et al., (2002) low intensity training at 40% $\dot{V}O_{2peak}$ demonstrates an increase in total fat

oxidation in obese men, where training at 70% of $\dot{V}O_{2max}$ did not affect

total fat oxidation, which is also consistent with the current study at

100% BW but not with the 75% BW condition. Fat oxidation rates

peaked at 40% $\dot{V}O_{2peak}$ and began to decrease steadily at the second

stage of exercise (6 minutes, 3.3 mph, 3% grade) in the 100% BW

condition at approximately 70% $\dot{V}O_{2peak}$ to below 0 where fat became

negligible. In the 75% BW condition fat oxidation rates stayed elevated

for an additional 3 minutes compared to the 100% BW condition where

at around 9 minutes rates began to decrease at approximately 70% of

the participants $\dot{V}O_{2peak}$ but did not become negligible. It is suggested

based on past and current research, to keep the percent gradient at

the level of maximal fat oxidation (3% grade) and perhaps more fat

would be oxidized over a longer period of time.

RER is the ratio of carbon dioxide (CO_2) produced to oxygen

consumed (O_2) consumed which is an indicator of which fuel is being

oxidized. According to Lusk (1928), an RER of .71 indicates 100% fat

oxidation. In the current study, PFO occurred in the first three minutes

at an RER of .85% in the 100% BW condition indicating 51.2% fat

oxidation. In the 75% BW condition PFO occurred up to nine minutes

at a higher RER of .86 and .87 indicating lower rates of fats oxidation

at 45.9% and 42.5%, respectively. Although RER increased

significantly as exercise intensity increased the overall message is that

exercise intensity needs to be lower than the current protocol in stage 4. The speed in the current study remained constant, so it would be suggested to decrease the percent grade to maintain elevated levels of fat oxidation.

Mean heart rate 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. Furthermore, four participants in the 100% BW group exceeded 85% of their maximal heart rate (HR_{max}), six participants were 20 to 40 beats below their 85% of HR_{max} 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. If these participants were able to go longer at a lower intensity, and the goal were to lose weight, the rate of weight loss may be dependent on the duration of the exercise session. As a result they may possibly increase fat oxidation, which could improve insulin sensitivity, where at higher exercise intensities that would not occur (van Aggel-Leijssen et al., 2002; Venables & Jeukendrup, 2008).

The mode of exercise also has an effect on fat oxidation where fat oxidation has been shown to be higher for a given oxygen uptake during walking and running compared to cycling (Jeukendrup et al., 2008). Most studies have used cycling where fat oxidation is 30% lower compared to treadmill walking, which has been suggested that it is due to the power output per muscle fiber in cycling compared to running (Achten et al., 2003). Furthermore, studies suggest that smaller mass will not elicit a large catecholamine response and as a result mobilization and oxidation of FFA is attenuated (Martin, 1996). The present study was the first study to be done on fat oxidation rates on a treadmill where one can unweight their body. The range of peak fat oxidation is considered moderate intensity, which is suggested by the American College of Sports Medicine for individuals interested in regulating their body weight and other health outcomes.

Fat oxidation rates when looking at weight-bearing and non-weight-bearing are different with increasing exercise intensities (Achten, et al., 2003). A few studies that determined PFO where the mode of activity was walking on a land treadmill all used a speed that may not be desirable for the overweight/obese sedentary population (Achten et al., 2003; Venables et al., 2005; 2008). Two studies (O'Deriaz et al., 2001; Bogdanis et al., 2001) used a speed that was desirable for the overweight/obese population. O'Deriaz et al., (2001)

used a walking speed of 2.7 mph with three gradients (3%, 5% and 6%) with his 58 middle-aged obese male participants and found that PFO occurred at 42% of the $\dot{V}O_{2max}$. Furthermore, Bogdanis et al., (2001) studied inactive overweight men and women approximately 36 years old and used a walking speed that was closer to the self-selected speed by overweight and obese individuals as determined by Browning et al., (2006). The treadmill speed in the present study on overweight/obese men, mean age of 24 was similar (3.3 mph) to the self-selected speed of walking according to Browning and Kram, (2005) and Minetti et al., (2003) (3.2 mph) and resulted in greater fat oxidation in the lower intensity exercise condition. Walking is a low intensity exercise and may be a preferable mode for overweight and obese individuals compared to cycling due to the large musculature of their legs and buttocks, which makes the body position uncomfortable. Moreover, walking at 75% BW demonstrated that the rate of fat oxidation at the same exercise intensity was greater than when compared to the 100% BW condition. Several studies have recommended that overweight individuals need to participate in low intensity exercise compared to normal weight individuals not only to promote exercise adherence but to maximize fat loss (ACSM, 2012; Perez-Martin et at., 2001; van Aggel-Leijssen et al., 2002).

Studies have shown that total fat oxidation during low intensity exercise was greater in obese than in normal weight individuals (Horowitz & Klein, 2000; Kanaley et al., 2001; & Goodpaster et al., 2002). In contrast, fat oxidation at different intensities in overweight/obese individuals showed a lower rate of fat oxidation than normal weight individuals (Perez-Martin et al., 2001; Bogdanis et al., 2005). In the present study, those who were in the reduced BW group showed an increase in fat oxidation at a lower intensity, which then began to decrease as intensity increased. Different body weights and distribution of body fat may affect substrate utilization during exercise.

It has been shown that fat oxidation rates can be reproduced in one individual however; several studies indicate there is a large inter-individual variation (Romain et al., 2012) as to where maximal fat oxidation occurs as can be seen in the current study.   A cross sectional study demonstrated that large differences exist in the ability to oxidize fat during exercise (Venables et al., 2005).   In the same study, fat oxidation rates were shown to range from 0.18 to 1.01 g/min. They concluded that the lean body mass, physical activity levels, $\dot{V}O_{2max}$, gender and fat mass accounted for 35% of the variation in peak fat oxidation rates, however 66% of the variance could not be explained. Although diet is likely to explain some the variance there is still a large part of the variance that remains unexplained.

Walking at 75% of one's BW enables the individual to reach their target heart rate at a lower HR and perceived effort (LaFortuna et al., 2008). The results of this study are consistent with Grabowski and Kram (2008; Grabowski, 2010; Figueroa et al., 2011; Raffalt et al., 2013) as they also found that as body weight decreased, there was also a significant decrease in RPE. When the RPE is decreased this may indicate that time to exhaustion can be longer and if one is able to walk longer, there is the potential to oxidize more fat ultimately burning more calories. Endurance exercise training and regular physical activity have been shown to increase total energy expenditure and lipid oxidation at rest (Blaak & Saris, 2002; Schrauwen et al. 2002) and during submaximal exercise in obese (van Aggel-Leijssen et al., 2002) and healthy lean subjects (Schrauwen et al. 2002).

Chapter VI

SUMMARY AND CONCLUSIONS

Fat oxidation is important in controlling body weight in both trained and untrained individuals.   In a recent meta-analysis, it is well confirmed that training at maximal fat oxidation (3 times per week) decreases fat mass, body weight and improves cholesterol (Romain et al., 2012). Furthermore, there has been a lot of interest in how to maximize fat loss for the purpose of weight control. The results of the present investigation provide practical implications for an optimal exercise prescription utilizing the anti-gravity treadmill. There also seems to be a large variation where peak fat oxidation occurs at a given intensity and has been suggested that this is a result of body composition, gender, and the type of exercise activity (Achten et al., 2003, Perez-Martin et al., 2001; Tarnopolsky, 2008).   Unweighting demonstrated the exercise intensity that promoted maximal fat oxidation occurred between 47% and 62% of $\dot{V}O_{2peak}$. Interestingly, a moderate intensity of 40% to 60% of $\dot{V}O_{max}$ is suggested by the American College of Sports Medicine (2012) for weight control and cardiovascular health in overweight and obese individuals.

There is also emerging evidence that LBPP devices appear to have a variety of benefits with no harmful effects in men, women and the elderly (Cutak et al., 2006). Therefore, LBPP training is a modality that is gaining

popularity to study unweighting the body during exercise without altering gait, heart rate or blood pressure. In conclusion, if the goal when prescribing exercise to the overweight/obese population is to increase fat oxidation then based on the results of the present investigation, it would be suggested to unweight the body to 75% at an exercise intensity between 40 and 65% of $\dot{V}O_{2peak}$ with no increase in percent grade past 3%.

Future Recommendations

Obesity research has become a priority, as obesity is a national concern. The current research provides a starting point investigating LBPP and fat oxidation in overweight and obese individuals. 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 fat loss. 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 maximizing fat as a fuel for exercise compared to simply promoting total caloric expenditure and more studies are needed to identify optimal training protocols for weight reduction in overweight and obese individuals.

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Appendix A

Recruitment flyer

**Volunteers Needed for
Research Study**

Do you want a personalized exercise program?

Title: The effects of walking on an antigravity treadmill on energy expenditure and fat oxidation in overweight and obese men with a BMI > 25 kg/m^2 and a body fat percent of >22.

Description of Project: We are undertaking a study to investigate whether walking on an antigravity treadmill that can reduce your body weight up to 75% can increase your ability to use fat as a fuel during exercise.

To participate: You must be a male between the ages of 18 – 35 and able to walk on a treadmill for 30 minutes at a low intensity. All subjects are volunteers and can quit at any time without penalty. All data will be secured on a flash drive in a locked cabinet and identifying marks will not be used in publication of the dissertation or subsequent journals.

Time: You will be asked to come to the Human Performance Lab at WPU 1 time for approximately 2 hours and then 1 more time for 1 hour per session. Each session will be separated by one week.

To learn more, contact the principle investigator of the study,
Toni LaSala at 973-720-2395 or lasalat@wpunj.edu.

This research is conducted under the direction of Dr. Genevieve Zipp, Department of Health Sciences, Seton Hall University and Dr. Michael Figueroa, Department of Kinesiology, William Paterson University, and has been reviewed and approved by the Seton Hall and William Paterson Institutional Review Board.

Appendix B

Informed Consent

Informed Consent
Seton Hall

INFORMED CONSENT FORM FOR PARTICIPANTS
Seton Hall University
Peak Fat Oxidation During Walking on the AlterG® Treadmill

Researchers Affiliation

Toni LaSala, full-time instructor at William Paterson University, and a Graduate student at Seton Hall University in the department of Graduate Programs in Health Sciences with a concentration in Movement Science is conducting a research study titled, The Effects of Walking on the AlterG® Treadmill on Peak Fat Oxidation Rates in Overweight/Obese Males. This research project will be conducted at William Paterson University and has been approved by the IRB at William Paterson.

Purpose

The purpose of this study will be to measure how well the body uses oxygen (peak oxygen consumption, $\dot{V}O2peak$), the type of fuel (carbohydrate and/or fat) the body uses, rating of perceived exertion or how hard a participant feels like they are working, blood pressure and heart rate responses while walking on a land treadmill. The participant will also walk at 100% and 75% of their original bodyweight on the AlterG® anti-gravity treadmill. When the choice is made to participate in this study, participants will be asked to report to the testing lab on four separate days for approximately 2 hours on the first session then 1 hour for the next three sessions.

Procedures:
Session 1: As part of the protocol the participant will be asked to report to the Human Performance Lab at William Paterson University to fill out a PAR-Q physical activity screening form, informed consent, and then participate in measurements of weight and height on a Detecto Physician's Scale with shorts and no shoes. The participant will proceed to the Underwater Tank to be weighed underwater for a body fat measurement. A belt of 3 kgs will then be secured around the

waist to insure that the participant will not float upward when underwater. The participant will then enter the tank and assume a seated position on a chair suspended from a scale in the water. To be sure all air bubbles are removed from inside the shorts, the participant will be instructed to pull the garment slightly away from the body around the legs and the top so that water can run inside it and replace the air entrapped there.

A practice session of getting weighed underwater will take place and the subject will take one or two deep breaths, submerge the upper body including their head and neck under the water as they stay seated on the bar and forcefully exhale as much air from the lungs as possible. At this point the participant will hold their breath and try to stay underwater for a count of 5 to 10 seconds. The researcher will be next to the tank and tap on the tank to tell the participant to come up. This procedure will be repeated 3 times.

Session 2: The participant will be prepped for measurements of heart rate and peak oxygen consumption both at rest and during exercise. The participant's chest hair may need to be shaved and cleaned prior to attaching twelve electrodes to designated areas of the chest to measure heart rate. Once all electrodes are in place, a resting heart rate and resting blood pressure will be recorded in a seated position. An exercise test to determine how well the body uses oxygen will be measured on a treadmill. The test will either be on the AlterG® anti-gravity or the land treadmill as determined by randomization of order. The participant will breathe through a mouthpiece so you can collect expired air to determine peak oxygen consumption. The mouthpiece is held in place by a mask that is attached by velcro to the back of the head and a clip that closes the nostrils. This will ensure that air is only traveling in and out of the mouth through the mouthpiece and not the nose.

The participant will then warm-up on one of the treadmills as per random order. If the AlterG® anti-gravity is randomly assigned, the participant will put on a pair of neoprene shorts that will zip into the anti-gravity treadmill before beginning the test. The participant will be required to walk at a speed of 2.0 mph 0% grade for the first 3 minutes, followed by an increase in treadmill speed to 3.3 mph where it remain for the entire test. The incline will be increased 3% every 3 minutes up to 15% or until the participant has reached 85% of their maximal heart (220-age x.85). The participant can request to stop the test at

any time. During this entire test, the ECG will measure heart rate during the last 15 seconds of each stage and blood pressure will be taken by the principal investigator during the last 30 seconds as well as pointing to a chart (Appendix G) to indicating how hard they are working.

Session 3: The third visit will include participation on a second treadmill test either on the AlterG® anti-gravity or the land treadmill in a random order. The procedures are the same as in Session 2.

Session 4: The final visit will include participation in a treadmill test either on the AlterG® anti-gravity or the land treadmill in a random order. The procedures are the same as in Session 2 and Session 3.

Voluntary Nature

Participation is entirely voluntary and may be ended at any time without any penalty or repercussions.

Anonymity and Confidentiality

Subjects identity will be protected at all times as names will not be revealed and no identifiable information will be used in this study. Toni LaSala and her dissertation committee will be the only persons with access to any confidential records. The results of the project may be published and will be available in the library and every attempt will be made to preserve anonymity. The data will be stored on a flash drive and destroyed at the conclusion of the project.

Risks and Discomforts

Potential risks from participating in this study include experiencing mild discomfort in the legs from walking, shortness of breath from fatigue and elevated heart rates associated with moderate intensity exercise. Every effort will be made to ensure the participants safety and comfort and should any situation arise, the emergency response system will be followed as posted clearly in the lab. All lab personnel are certified in CPR/AED and First Aid and the lab is equipped with a telephone where the phone number of the Campus Police is clearly posted as well as an AED, which is readily available.

Immediate medical attention is available through the Health Services Center at William Paterson University or at the local hospital located next to the campus.

Direct Benefits

The possible benefits of participation in this research is learning about current fitness levels as well as obtaining an exercise prescription.

Monetary Compensation

There will be no compensation for participation in this study.

Alternative Procedures

There are no alternative procedures or courses of treatment that may be advantageous to the study.

Contact Information

Any questions regarding the research study and participation before or after consent, will be answered by the principal investigator, Toni LaSala at, 300 Pompton Road, Wayne, NJ, 07470, Office - Wightman Gym 121 or at (973) 720-2395. Additional information can be obtained from the faculty advisor, Dr. Genevieve Zipp, (973) 275-2457, the Chair of the Institutional Review Board, Dr. Mary Ruzicka (973- 275-2723), Seton Hall University, 400 South Orange Ave, South Orange, NJ, 07079 or Martin Williams at the Institutional Review Board of William Paterson University, 300 Pompton Rd. Wayne, NJ, 07470, (973-720-2852).

Signatures

I have read the above information concerning this project and understand about the nature, demands, risks and benefits of the project as they have all been explained to me. All my questions have been answered to my satisfaction. I understand that I am free to request further information at any stage. I also understand the risks involved and understand that I am free to withdraw my consent and discontinue participation at any time without penalty or loss of benefit to myself. In signing this consent form, I am not waiving any legal claims, right, or

remedies. A copy of this signed and dated consent form will be given to me.

Name of Subject_____
Signature of Subject_____

Date: _____

    I certify as the principal investigator that I have explained to the above individual the nature, purpose, potential benefits and possible risks associated with the participation in this research study. I certify that I have answered any questions that have been asked, and have witness the signature above. I have provided the subject with a copy of the signed consent document.

Name of Subject_____
Signature of Subject_____

Date: _____

Appendix C

Physical Activity Readiness Questionnaire (PAR-Q)

PAR-Q and YOU
(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 to 69, the Par-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly. Check YES or NO.

YES	NO	
❏	❏	1. **Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?**
❏	❏	2. **Do you feel pain in your chest when you do physical activity?**
❏	❏	3. **In the past month, have you had chest pain when you are not doing physical activity?**
❏	❏	4. **Do you lose your balance because of dizziness or do you ever lose Consciousness?**
❏	❏	5. **Do you have a bone or joint problem (for example, back, neck, knee, or hip) that could be made worse by a change in your physical activity?**
❏	❏	6. **Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?**
❏	❏	7. **Do you know <u>any other reason</u> why you should not do physical activity?**

if

you

answered

YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want—as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful to you.

NO to all questions

If you answered NO honestly to <u>all</u> PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

DELAY BECOMING MUCH MORE ACTIVE:

- If you are not feeling well because of a temporary illness such as a cold or a fever – wait unit you feel better; **or**
- If you are or may be pregnant – talk to your doctor before you start becoming more active.

PLEASE NOTE: If your health changes so that you then answer YES to any of the above questions, tell you fitness or health professional. Ask weather you should change your physical activity plan.

<u>Informed use of the PAR-Q:</u> The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completion of this questionnaire, consult your doctor prior to physical activity.

<u>NOTE:</u> If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

NAME: _____

SIGNATURE: _____   DATE: _____

SIGNATURE OF PARENT: _____   WITNESS:_____
or GUARDIAN (for participants under the age of majority)

NOTE: This physical activity clearance is valid for a maximum of 12 months form the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.

ParQ_0805

Appendix D

Instrumentation

Instruments

AlterG® anti-gravity Treadmill

Neoprene Shorts

Subject Entry into Treadmill

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Appendix E

Data Collection Sheet

Alter-G® Anti-Gravity Treadmill Data Sheet

Test:_____Temperature:_____ Humidity:_____

ID#		Birthdate		Age	
Pre-ex HR		HRmax		85% HRmax	
Pre-ex BP		Height (in)		Height (m)	
Waist Circumference		Weight (lbs)		Weight (kg)	
Hip Circumference		%Body Fat		Date	
Waist to Hip Ratio		BMI		Time	

Balke-Ware Protocol
3-minute stages

Stage	Speed (mph)	% Grade	BP	HR	RPE	RER	$\dot{V}O_2$ ml/kg/min	$\dot{V}O_2$ ml/min	$\dot{V}CO_2$ ml/min
1	2.0	0							
2	3.3	3							
3	3.3	6							
4	3.3	9							
5	3.3	12							
6	3.3	15							
Rec 2 min									
Rec 4 min									
Notes:									

Appendix F

IRB Approval William Paterson University

THE WILLIAM PATERSON UNIVERSITY OF NEW JERSEY
INSTITUTIONAL REVIEW BOARD FOR HUMAN SUBJECT RESEARCH

c/o Office of Sponsored Programs	Chair: Professor Michael Figueroa (FigueroaM@wpunj.edu)
Raubinger Hall, Room 309	College of Science and Health
973-720-2852 (Phone)	Contact: Martin Williams (williamsm@wpunj.edu)
973-720-3573 (Fax)	Office of Sponsored Programs
http://www.wpunj.edu/osp/	

To: Toni LaSala
        Department of Kinesiology

From: Martin B. Williams *Martin B. Williams*

Subject: IRB Approval (Expedited Review)

Study: Protocol # 2014-321: The Effects of Walking on the AlterG Treadmill on Energy
          Expenditure and Fat Oxidation in Overweight/Obese Males.

Date: November 22, 2013

The IRB has APPROVED the above study involving humans as research subjects. This study was
approved as: Category: <u>Expedited</u>; vulnerable population: WPU Students and Employees.

IRB Number: 2014-321   This number is WPU's IRB identification that should be used on all
                            consent forms and correspondence.

Approval Date: 11/21/2013
<u>Expiration Date:</u>   **11/20/2014**

**This approval is for one year. It is your responsibility to insure that an application for continuing
review approval (WPU IRB Form Appendix D) has been submitted before the expiration date
noted above.** If you do not receive approval before the expiration date, all study activities must stop until
you receive a new approval letter. There will be no exceptions. In addition, you are required to submit an
Appendix D form at the conclusion of the project. The WPU IRB will accept a report submitted to
another office or agency (i.e. ART report) in lieu of the narrative report of progress attachment to
Appendix D. The Appendix D can be accessed at: http://ww3.wpunj.edu/osp/ .

Consent Form: All research subjects must use the approved Informed Consent Form. You are
responsible for maintaining signed consent forms (if approved for Active Consent format) for each
research subject for a period of at least three years after study completion.

Mandatory Reporting to the IRB: The principal investigator must report immediately any serious
problem, adverse effect, or outcome that is encountered while using human subjects or any complaints
from your subjects. In addition, the principal investigator must report any event or series of events that
prompt the temporary or permanent suspension of a research project involving human subjects or any
deviations from the approved protocol using Appendix D.

Amendments/Modifications: You are required to carry out this research as described in the protocol. All
amendments/modifications of protocols involving human subjects must have prior IRB approval, except

Appendix G

IRB Approval Seton Hall University

SETON HALL UNIVERSITY

1 8 5 6

May 21, 2014

Toni LaSala
23 Allen Drive
Wayne, NJ 07470

Dear Ms. LaSala,

The Seton Hall University Institutional Review Board has reviewed the information you have submitted addressing the concerns for your proposal entitled "The Effects of Walking on the AlterG® Treadmill on Peak Fat Oxidation Rates in Overweight/Obese Males". Your research protocol is hereby approved as revised under full review.

Enclosed for your records are the signed Request for Approval form, the stamped original Consent Form and recruitment flyer. Make copies only of these stamped forms.

The Institutional Review Board approval of your research is valid **until March 31, 2015**. During this time, any changes to the research protocol must be reviewed and approved by the IRB prior to their implementation.

According to federal regulations, continuing review of already approved research is mandated to take place by **March 31, 2015**. You will receive communication from the IRB Office for this several months before this date.

Thank you for your cooperation.

In harmony with federal regulations, none of the investigators or research staff involved in the study took part in the final discussion and the vote.

Sincerely,

Mary F. Ruzicka, Ph.D.
Professor
Director, Institutional Review Board

cc: Dr. Genevieve Pinto Zipp

Office of Institutional Review Board
Presidents Hall · 400 South Orange Avenue · South Orange, New Jersey 07079 · Tel: 973.313.6314 · Fax: 973.275.2361 · *www.shu.edu*

A   HOME   FOR   THE   MIND,   THE   HEART   AND   THE   SPIRIT

Appendix H

Copyright Permissions

Dear Dr. LaSala,

Permission is granted to reproduce the PAR-Q as proposed, in the manuscript referenced below.

All the best with your research,
Mary Duggan, CAE
Manager
Canadian Society for Exercise Physiology
370-18 Louisa Street | Ottawa, Ontario K1R 6Y6
T 1-877-651-3755 x 223 | F 613-234-3565 | www.csep.ca
Social Media: | |

To Whom It May Concern:

AlterG grants Toni LaSala, Ph.D permission to use our images in her dissertation
titled, "The Effects of Walking on the AlterG Anti-Gravity Treadmill on Fat Oxidation inOverweight/Obese Men". She has permission to use three images, two of the Anti-Gravity treadmill and one of the AlterG shorts. Should you have any questions please contactmarketing@alterg.com

Thank you,
Megan Chen
Marketing Programs Specialist