Comparing Energy Expenditure During Land and Shallow Water Walking in Overweight and Obese Females

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COMPARING ENERGY EXPENDITURE DURING LAND AND SHALLOW WATER WALKING IN OVERWEIGHT AND OBESE FEMALES

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Introduction: The prevalence of overweight and obesity in the United States has reached epidemic levels. Reduction in body weight is of great importance for overweight and obese individuals through the increase in physical activity. One particular mode of physical activity that is currently growing in popularity is shallow water walking, although little research has been done examining the energy cost of this activity in an overweight and obese population. **Purpose**: To compare the energy expenditure (kcal/min) and rating of perceived exertion (RPE) of a bout shallow water walking at a self-selected pace to a bout of land walking at a matched heart rate response and to a bout of land walking at a self-selected pace in overweight and obese women. **Methods**: Nineteen participants completed three 10-minute experimental trials including a self-selected pace shallow water walking trial, a matched heart rate response land walking trial, and a self-selected pace land walking trial. **Results**: Significantly lower energy expenditure ($p = 0.046$) was observed for shallow water walking (6.46 ± 1.38 kcal/min) compared to the matched heart rate response land walking bout (7.26 ± 1.29 kcal/min), although no significant differences were detected for energy expenditure for shallow water walking and self-selected pace land walking (6.92 ± 1.61 kcal/min). No significant differences were detected for RPE across conditions ($p=0.439$). Exploratory analyses revealed correlations between measures of body composition (BMI and percent body fat) and the difference in energy expenditure between shallow water walking and matched heart rate response land walking. **Conclusions**: Findings from the current study suggest that although producing energy expenditure compared to heart rate matched land walking, shallow water

walking is a viable alternative that can elicit and increase in energy expenditure performed at a moderate intensity, meeting ACSM criteria. Results of the exploratory analyses revealed an association between measures of body composition and differences in energy expenditure. Although only a limited number of participants of the present study had BMI's above 35.0 kg/m^2 (n=2), findings suggest that water exercise may be an alternative form of exercise and produce higher caloric expenditure at higher ranges of BMI and percent body fat.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

PREFACE

Thank you to my committee members as well as my wonderful family, friends, coworkers for your constant love and support. I could not have done it without each and every one of you.

1.0 INTRODUCTION

1.1 OBESITY AND PHYSICAL ACTIVITY

The prevalence of overweight and obesity in the United States has reached epidemic levels with approximately 69% of adults classified as overweight (Body Mass Index (BMI) ≥ 25.0 kg/m^2) and more than one third (36%) of Americans classified as obese (BMI ≥ 30.0 kg/m^2).[1] Overweight and obesity are associated with higher rates of all-cause mortality[2], as well as an increased risk for several chronic diseases including cardiovascular disease, type II diabetes mellitus, certain forms of cancer, and osteoarthritis.[3] As a major contributor to preventive death in the United States today, overweight and obesity pose a major public health challenge,[4] and has been extensively researched over the past few decades. One such area of research is the contribution of physical activity to the prevention and treatment of obesity.

While traditionally considered a disorder primarily of energy intake, accumulating evidence is highlighting the role of energy expenditure in the development and treatment of obesity.[5,6] Furthermore, physical inactivity has been demonstrated to be a clear contributor to obesity and is now considered a leading cause of death in the United States.[7] Accounting for 5% - 40% of total daily energy expenditure,[8] physical activity is considered the most variable component and can influence the development of obesity as well as the success in achieving both initial and long term weight loss. Although not consistent in the literature, some evidence shows that physical activity only modestly contributes to weight loss in overweight and obese adults compared to dietary modification through caloric restriction,[4] while other controlled trials show that exercisers lose significantly more weight than non-exercisers.[9] However, it is important to emphasize that individuals who are successful at maintaining their weight loss consistently report regular exercise, whereas weight regainers do not.[4,10,11] Furthermore, evidence shows that the addition of physical activity to a reduced-calorie diet produces greater weight loss than diet alone or physical activity alone.[4]

The mechanisms by which exercise improves weight loss have been attributed to both physiological and psychological factors.[12,13] In addition to expending calories and therefore increasing energy expenditure, physical activity also protects against the loss of lean body mass,[13,14] improves cardiorespiratory fitness, reduces obesity-related cardiometabolic health risks, and promotes a sense of well-being.[12] Furthermore, increased physical activity may minimize the reductions in resting energy expenditure that accompany a reduced-calorie diet, possibly by increasing sympathetic nervous system activity.[14,15] This, along with the attenuated loss of lean body mass further preventing the reduction in resting energy expenditure, could help to prevent the slowing in weight loss and even future weight regain that dieters frequently experience. With this is mind, physical activity appears to be a significantly important behavior for short and long-term weight control in overweight obese individuals.[4-6,14]

1.2 AQUATIC EXERCISE

Reduction in body weight is of great importance for overweight and obese individuals through the increase in physical activity. One particular mode of physical activity that is currently growing in popularity is aquatic exercise, utilizing land-based physical activity (i.e. walking, jogging, calisthenics, and additional locomotor/resistive movements) adapted to a water medium.[16] One particular aspect of aquatic exercise of recent interest is shallow water walking, which is an aerobic activity that does not require prior swimming skill.[17] Although there is sufficient evidence to support the metabolic, cardiovascular, and psychological benefits of aquatic exercise,[16,18-30] little research has been done examining the energy cost.

Although the minimal existing intervention data is promising, showing equal reductions in body weight and body fat with aquatic compared to land-based forms of exercise,[31,32] the acute physiological responses to water-based exercise are not well understood. Research has compared the gold standard exercise modality, treadmill running, to many other modalities including cycling, simulated cross-country skiing, rowing, and stepping, showing treadmill running to elicit the highest energy expenditure and oxygen consumption.[33] However, solid evidence regarding energy expenditure does not currently exist for aquatic exercise. Some research has hypothesized that effects of water buoyancy, resulting in up to 90% reduction in body weight, as well as resistance due to the exponentially higher density of water than air make it possible to expend high levels of energy while at the same time reducing strain and impact force on lower extremity joints.[34,35] Furthermore, a higher percentage of body fat will potentially increase buoyancy during water immersion resulting in a greater relative energy expenditure at a given workload due to the additional forces and movements required to counteract the effects of added buoyancy while immersed.[36] Thus the water environment could potentially allow for high levels of energy expenditure relative to comparable land-based exercise, although this hypothesis has not been confirmed. Therefore, knowledge of the expected physiological responses and estimated energy cost of a given exercise is necessary for the clinician to make decisions on safe and effective exercise programs.[35,37]

One potential benefit of water based exercise over land based exercise is the partially weight bearing mode. In overweight and obese individuals, the rationale for recommending regular physical activity to lose weight is that the energy expenditure associated with the activity has the potential to generate a negative energy balance. The use of regular exercise in the treatment of these patients is thus strongly influenced by their ability to exercise. However, some research states that these patients may not be able to tolerate weight-bearing aerobic activities of sufficient duration to achieve body composition changes due to the strain excess body weight puts on their joints,[14] although not conclusive.[38]

Overweight and obese individuals are typically prescribed and can engage in land-based activities such as walking that are performed at a moderate intensity due to its practical nature and convenience.[39,40] However, severely obese individuals, particularly those with a BMI of 40 kg/m^2 and above, may have difficulty performing generally prescribed physical activity. Prolonged weight bearing exercises can even cause musculoskeletal problems in this population with no previous history of joint disease,[41,42] potentially forcing them to discontinue their programs and cease weight loss efforts. Furthermore, obesity and overweight are associated with musculoskeletal pain, as well as with osteoarthritis of the knee and hip.[43-45] Excess body weight is a powerful predictor of the development of osteoarthritis, with every 5kg of weight gain increasing the risk of knee arthritis by 35%.[12] This is most likely due to the 60% greater ground reaction forces at the knee during walking in obese patients than in normal weight patients.[12] Consequently, there is mounting evidence to support that obese individuals have a reduced exercise tolerance, especially when BMI is greater than 40 kg/m^2.[46] Furthermore, the net metabolic rate of walking in overweight and obese participants is approximately 10-45% greater than in normal weight individuals.[47,48] This added metabolic cost places them at a greater percentage of their maximum aerobic capacity, making it more difficult to maintain recommended exercise durations. Therefore, the standard prescription of brisk walking for long durations and high frequency, even at a lower intensity (30-50% VO_{2max}), may be perceived as too strenuous.[46]

Thus, obese individuals may find water to be a desirable environment for exercise due to the cushioning effect of exercise in water potentially preventing injuries caused by excessive strain on the joints of the lower extremities, experience less heat stress during immersion permitting more efficient heat dissipation due to water's comparatively higher specific heat and thermoregulatory characteristics, and may be perceived as less strenuous.[31,33,35,49] For these reasons, water walking as a part of an aquatic exercise program may be considered an effective alternative to land-based exercise as well as provide unique benefits that land-based exercise does not for individuals with a body weight problem,[34] although an under-studied and currently limited area of research. In conclusion, although aquatic exercise may serve as an alternative mode of exercise, the relative energy cost is currently unknown compared to the land alternative in overweight and obese individuals.

1.3 GAPS IN THE LITERATURE

The current body of literature regarding the energetic profile of aquatic exercise is conflicting with several investigations reporting higher energy expenditure on land compared with aquatic exercises,[50-52] although other investigations have reported higher physiological responses in water.[53,54] Within these studies the inconsistent exercise protocols and methods of standardizing workload and intensity between the land and water modalities have potentially led to the variability of the results. Furthermore, existing research has focused primarily on the physiological responses to deep water walking/running or water based resistance training and callisthenic exercises, although not as commonly practiced in community based aquatic programs as shallow water exercise. Existing research is focused on a primarily healthy, young, normal weight population rather than an overweight and obese population. Therefore, current work with aquatic exercise and with any comparison to land-based exercise has been confounded with study limitations, and some factors suggesting that aquatic exercise may be a viable alternative to land-based exercise for overweight adults may be based on assumptions rather than on empirical data. Thus before aquatic exercise can be recommended as a comparable activity for overweight and obese individuals, more studies are needed. A first step in this line of research is to compare the energy expenditure during a bout of land walking and shallow water walking in overweight and obese women.

1.4 SPECIFIC AIMS

The specific aims of the proposed study were:

1. To compare the energy expenditure ($kcal \cdot min^{-1}$) of a bout shallow water walking at a self-selected pace to a bout of land walking at a matched heart rate response to a bout of land walking at a self-selected pace in overweight and obese women.

2. To compare the perceived exertion (RPE) during a bout of shallow water walking at a self-selected pace to a bout of land walking at a matched heart rate response to a bout of land walking at a self-selected pace in overweight and obese women.

1.5 HYPOTHESES

The hypotheses for the specific aims of the proposed study were:

1. The energy expenditure will be significantly higher during a bout of shallow water walking at a self-selected pace compared to a bout of land walking at a matched heart rate or a bout of land walking at a self-selected pace.
2. The perceived exertion will be significantly lower during a bout of shallow water walking at a self-selected pace compared to a bout of land walking at a matched heart rate response or a bout of land walking at a self-selected pace.

1.6 SIGNIFICANCE

Understanding the energy cost of an activity is valuable for weight-reduction programs including an exercise prescription.[55] Although aquatic exercise may be considered a desirable alternative exercise modality for overweight and obese individuals, the caloric cost of the activity should be considered[8] and difficulties may arise if the prescribed relative energy cost is based on land based activities. Researchers have even stated that the use of land-based prescriptive norms would underestimate the metabolic cost in water.[56] This demonstrates a need to identify an accurate quantification of energy cost of aquatic exercise for an overweight and obese population. This study aimed to address the gaps in the literature regarding the energy cost of a bout of water walking compared to a bout of land walking in a sample of overweight and obese women. It was hypothesized that the energy expenditure would be higher during a bout of shallow water walking than during a matched bout of land walking, as well as elicit lower levels of perceived exertion. A significantly higher energy expenditure and lower levels of perceived exertion, or similar levels of both, during a matched bout of water exercise would warrant further research of the chronic effects of aquatic based exercise as an alternative mode of physical activity in overweight and obese individuals.

2.0 REVIEW OF LITERATURE

2.1 INTRODUCTION

Overweight and obesity are leading risk factors for premature mortality and numerous chronic health conditions that reduce the overall quality of life including type 2 diabetes, coronary heart disease, hypertension, stroke, certain forms of cancer, gallbladder disease, and osteoarthritis.[4,57] Overweight and obesity are commonly assessed in the research and clinical setting using the Body Mass Index (BMI), calculated as weight in kilograms divided by the square of height in meters (kg/m^2).[58] The globally accepted BMI classification system for adults identifies a normal BMI between 18.5-24.9 kg/m^2, overweight between 25-29.9 kg/m^2, and obese above 30 kg/m^2.[57] Furthermore, several large epidemiologic studies have found that increasing BMI is associated with an increased risk of mortality.[59,60] Data from the prospective Cancer Prevention Study II shows the mortality curve as a continuum that begins to increase at a BMI of 25 kg/m^2.[60] With the prevalence in the United States reaching epidemic levels with approximately 69% of adults classified as overweight and more than one third (36%) of Americans classified as obese,[1] it is well-understood that overweight and obesity pose a significant public health challenge.[4]

2.2 OBESITY AND PHYSCIAL ACTIVITY

2.2.1 Role of Physical Activity in Weight Management

Obesity is a result of a chronic positive energy balance, accompanied by unhealthy weight gain, and is linked to physical inactivity.[58] Furthermore, changes in body weight are related to alterations in energy balance. On one side of the energy balance equation is energy intake, primarily dependent on calories consumed. The other side of the equation is energy expenditure, comprised of basal metabolic rate, thermogenesis, and physical activity.[8] By maintaining balance between energy intake and energy expenditure, energy balance and weight maintenance is achieved. However, weight gain occurs when there is a chronic increase in caloric intake compared to energy expenditure.[8] Contrastingly, when weight loss is desired, it is necessary to create an energy deficit where energy expenditure exceeds energy intake.

While traditionally considered a disorder primarily of energy intake, accumulating evidence is highlighting the role of energy expenditure in the development and treatment of obesity.[5,6] Using the doubly-labeled water method to measure energy expenditure, Shulz & Schoeller reported a decrease in physical activity (non-RMR energy expenditure) in direct relationship to the degree of obesity.[61] Furthermore, physical inactivity has been demonstrated to be a clear contributor to obesity and is now considered a leading cause of death in the United States.[7] Accounting for 5% - 40% of total daily energy expenditure,[8] physical activity is considered the most variable component and can influence the development of obesity as well as the success in achieving both initial and long term weight loss. However, only 48.4% of adults meet the Physical Activity Guidelines of 150 minutes of moderate-intensity aerobic activity every week or 75 minutes of vigorous-intensity aerobic activity every week.[62]

The current recommendations from The National Heart Lung and Blood Institute (NHLBI) Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults include physical activity as part of a comprehensive weight loss therapy and weight maintenance program because it: (1) modestly contributes to weight loss in overweight and obese adults, (2) may decrease abdominal fat, (3) increases cardiorespiratory fitness, and (4) may help with maintenance of weight loss.[4] Furthermore, it has been shown that the combination of a reduced calorie diet and increased physical activity produces greater weight loss than diet alone or physical activity alone.[4] Low calorie diet interventions without the inclusion of a physical activity intervention have been shown to reduce total body weight by an average of 8% over three to twelve months, as well as decrease abdominal fat accompanied by significant reductions in waist circumference.[4] Physical activity interventions result in only modest weight loss (3kg in men and 1.4kg in women compared to controls), independent of the effect of caloric reduction through diet.[4] Furthermore, a dose response relationship exists with physical activity alone typically only resulting in a 2-3 kg weight loss with >150 minutes per week or 5-7.5 kg weight loss with 225-420 minutes per week according to the American College of Sport Medicine.[63] Other trials including the Midwest Exercise Trial showed no significant decrease in weight due to exercise alone in women.[64] However, when combined with caloric restriction, numerous other studies have observed that increased physical activity resulted in an average of 5.3 kg greater weight loss and a 0.9 greater change in BMI unit than the physical activity-alone groups,[65-67] as well as a non-significantly greater weight loss compared to a diet only group.[68]

Additionally, physical activity appears to have a favorable effect on distribution of body fat.[69] Physical activity has been shown to influence the attenuation of fat free mass (FFM) loss due to caloric restriction and weight loss.[70] According to a meta-analysis by Garrow and Summerbell, it was concluded that for a weight loss of 10 kg by diet alone, the expected loss of FFM is approximately 2.9 kg in men and 2.2 kg in women. When similar weight loss is achieved by exercise combined with dietary restriction the expected loss of FFM is reduced to 1.7 kg in men and women.[71] Furthermore, a clear dose response relationship is evident between increasing dose of weekly exercise (low amount/moderate intensity, low amount/vigorous intensity, high amount/high intensity) and decreases in measurements of central obesity and total body fat mass, reversing the effects in the non-exercising control group.[72] Finally, several large cross-sectional studies showed an inverse association between energy expenditure through physical activity and several indicators of body fat distribution, such as waist-to-hip circumference ratio and waist-to-thigh circumference ratio.[73-77] However, it is not known whether the effects of physical activity on abdominal fat are independent of weight loss.

2.2.2 Physical Activity and Short Term vs. Long Term Weight Management

As previously mentioned, it is understood that physical activity only modestly contributes to initial weight loss (during the first 6 months). However, there is a vast majority of research that suggests that physical activity may play a role in long-term weight control and/or maintenance of weight loss.[4] Numerous randomized control trials found that over a longer duration of 9 months to 2 years, the addition of physical activity as part of a combination therapy resulted in approximately 1.5 to 3kg greater weight loss than diet alone.[78-80] Additionally, Jakicic and colleagues observed a dose-response relationship between amount of physical activity and weight loss over an 18-month period. In this study, individuals completing <150, 150-200, and >200 minutes per week of exercise observed an average weight loss of 3.5 kg, 8.5 kg, and 13.1 kg, respectively.[81]

Furthermore, several longitudinal studies with up to 10 years of follow-up results have observed that physical activity is related to less weight gain over time.[82-85] Williamson et al. reported that the relative risk of major weight gain (>13kg) for people whose activity level was low at baseline and at 10-year follow up time point was 2.3 times higher in men and 7.1 times higher in women compared to individuals whose activity levels were high at baseline and 10 years. Additionally, The National Weight Control Registry, comprised of individuals who have lost over 30 pounds and maintained that weight loss for at least 1 year, shows that successful maintainers expend an average of 2700 kcals per week, equivalent to approximately 70 minutes per day of moderate intensity activity.[86]

2.2.3 Additional Benefits of Physical Activity

In addition to the increase in total daily energy expenditure and influences on body composition, there are numerous health related benefits of physical activity, specifically the modification of risk factors for cardiovascular disease such as hypertension, hyperlipidemia, and diabetes. First, physical activity has been shown to have both an acute and chronic effect on blood pressure (BP). The acute response to exercise includes an increase in systolic blood pressure (SBP) during exercise, followed by a decrease in SBP (average of 15 mmHg)[87] following aerobic exercise and may remain below pre-exercise values for up to 22-hours.[88] The chronic BP response due to physical activity training can result in a decrease in resting BP and decreased BP response to a given submaximal exercise intensity.[89] Furthermore, exercise training can decrease SBP and diastolic blood pressure (DBP) 2-4 mm Hg in normotensive patients,[90,91] although this response is more pronounced in hypertensive patients (5-7 mm Hg).[89,91,92] This response is likely due to decrease in total systemic peripheral resistance. During exercise there is a redistribution of blood flow to allow skeletal muscle to provide additional blood and oxygen to working muscles. This results in arterial vasodilation in these areas, some of which remains following exercise. It is also thought that increased vasodilator substances play a role in the transient decrease in BP following exercise.[89] Furthermore, epidemiologic studies have examined the associations between various types of physical activity and the incidence of hypertension, reporting a protective effect of vigorous exercise in male university alumni against future hypertension.[93,94] Others have investigated relationships between measured physical fitness and incident hypertension, reporting persons with low physical fitness had a relative risk of 1.5 for the development of hypertension when compared with highly fit persons, after controlling for age, sex, body mass index, and BP.[93]

Physical activity may also contribute to observed benefits seen with hyperlipidemia, such that exercise has been shown to increase high-density lipoprotein–cholesterol (HDL-C) and decrease triglycerides (TG), although there is not much evidence to support changes in total cholesterol or low-density lipoprotein-cholesterol (LDL-C). Cross-sectional data suggests that with weekly energy expenditure from physical activity between 1200 and 2200 kcals, an observed 2 to 3 mg/dl increase in HDL-C and reductions of 8 to 20 mg/dl in TG, with greater changes in HDL-C with additional increases in exercise training volume.[94]

Physical activity has also been shown to influence the development and treatment of type 2-diabetes mellitus (T2DM). Several epidemiological studies have examined the association between physical activity levels and risk of T2DM, unanimously reporting that higher physical activity levels are associated with reduced risk, regardless of variability in methodology,[95-97] as well as the reduced risk associated with greater fitness levels.[98,99] Acutely, physical activity cause increased glucose uptake into active muscle with a greater reliance on carbohydrate to fuel muscular activity. Muscular contractions increase blood glucose transport by a mechanism not impaired by insulin resistance (and is separate from insulin-stimulated blood glucose transport), and may improve insulin action for 2-72 hours following activity. Exercise can influence insulin signaling though muscle contraction stimulated GLUT4 translocation in skeletal muscle, whereas resistance training enhances skeletal muscle mass, which may increase blood glucose uptake. Furthermore, chronic aerobic and resistance training improve insulin action and blood glucose control.[100]

Physical activity also contributes to improvements in fitness levels, which have been associated with risk reduction. According to Blair et al., the lowest level of fitness is associated with highest mortality relative risk,[101] and has a higher all-cause mortality relative risk than other risk factors.[102] Furthermore, all-cause mortality risk is 3 fold higher in men and 4 fold higher in women from lowest to highest fitness level.[102] Additionally, a few studies have examined the relative risk associated with fitness levels, independent of BMI status. Wei and colleagues reported that unfit obese men have two times higher all-cause mortality relative risk than a fit obese man,[103] and Wessel and colleagues reported that women who were unfit had the greatest risk of cardiovascular disease events regardless of their BMI category.[104]

2.3 AQUATIC EXERCISE

Water-based exercise is rapidly growing in popularity as a potential alternative to land based exercise for numerous populations including overweight and obese individuals. Aquatic exercise is an umbrella term for a multitude of water-based exercise modes utilizing land-based physical activity adapted to a water medium,[16] and include swimming, shallow water walking/running, deep-water walking/running, aqua-aerobics, or the use of an aquatic treadmill. Much research has been conducted over the past few decades to describe the acute and chronic responses of head-out water-based exercise for both therapeutic and sport performance application, although much variation exists within the literature, spanning a wide age range, weight/BMI status, fitness levels, exercise mode, and exercise intensity. Although historically aquatic research has been typically focused in competitive swimming, is appears that recent interest has shifted toward vertical water-based exercises.[105] Of this, the vast majority of more recent research has focused on deep-water walking/running or water based resistance training and callisthenic exercises, although not as commonly practiced in community based aquatic programs as shallow water exercise. Furthermore, interest in shallow water walking has grown recently, due to its ease of application not requiring prior swimming skill.[17] Therefore, understanding the physiological responses of shallow water-based exercise is an understudied, yet crucial area of research. In order to describe and quantify such adaptations, the physiological assessment of several parameters is necessary, although sparsely described in the literature. For the purpose of this review of literature, acute adaptations are evaluated using oxygen consumption (VO_2), heart rate, energy expenditure (kcal), and ratings of perceived exertion (RPE), with aerobic capacity and body weight/body composition changes used to evaluate chronic adaptations.

2.3.1 Physiological Responses to Water vs. Land-Based Exercise

Maximal aerobic capacity is an important indicator of functional capacity, and is an independent risk factor for cardiovascular and all-cause mortality when low.[101,106] Few investigations have examined the effect of water-based exercise training on changes in cardiorespiratory fitness, although the results have been favorable. Research has shown that relative improvements in VO_{2peak} have been observed ranging from 5% to 42%.[25,55,107-111] Takeshima and colleagues reported a 12% increase in VO_{2peak} in a group of sedentary older women during a 12-week water exercise intervention, similar to the results reported by Taunton et al.[107,110] However, other researchers have reported greater improvements (22%-42%) in individuals with lower baseline fitness levels.[55,108] Furthermore, when compared to a land-based exercise control, it was found that the improvements observed in the water-based exercise group were similar to that of the land-based control.[30,32,109,112]

However, chronic adaptations represent the accumulation of acute responses during each aquatic session, although much more scarcely examined in the literature. Data on the acute cardiorespiratory response to water-based exercise is also conflicting based on the mode of water-based exercise. As previously mentioned, the majority of the existing literature investigated the acute response to deep water running (DWR) and observed lower maximal and submaximal VO_2 compared to land.[56,113-115] Contrastingly, studies examining the cardiorespiratory response in shallow water using ATM compared to land based exercise have observed higher VO_2 in the water than on land.[17,52,54,116-118] Hall and colleagues matched the exercise bouts using walking speed and reported similar VO_2 at a slower speed (3.5 kph), but significantly higher VO_2 in the shallow water at 4.5 and 5.5 kph,[52] although Masumoto et al. observed significantly higher VO_2 while walking at a slower speed of 2.4 kph in water versus land, potentially due to variations in water depth. Additionally, two studies by Migita et al. and Shono et al., reported that half the speed was required on land to achieve the same VO_2 response in water.[17,118] When matching on heart rate, Darby and Yaekle reported that water elicited 2-6 $ml \cdot kg^{-1} \cdot min^{-1}$ greater oxygen consumption in water than land.[116] Silvers and colleagues later confirmed this, reporting lower heart rates in water than land at a similar VO_2.[54]

The majority of studies examined the heart rate response, likely due to the ease of data collection. However, it is important to discuss the unique characteristics and influences on the heart rate response to the water medium. In humans, head-out immersion in water (with upward directed hydrostatic pressure gradient) leads to a central shift of blood volume from the periphery to the thorax. This results in several cardiorespiratory adjustments including an increase in central venous pressure, increase in cardiac blood volume, and a 25% or more increase in stroke volume and cardiac output, resulting in a decrease in heart rate.[115] Furthermore, water temperature has a substantial influence on heart rate. Craig and Dvorak reported that exercise in water at 25°C has been shown to produce a lower heart rate response than on land at a similar VO_2, although raising the temperature to 30°C show little difference[119] later confirmed by McArdle and colleagues, reporting lower heart rate response in water compared to land at 18°C and 25°C.[120] The combined influence of water temperature and hydrostatic pressure result in a lower heart rate in the water compared to land at a given VO_2. This has been demonstrated in a number of studies including a variety of water depths and walking speeds concluding that for a given VO_2, heart rate was approximately 9-20 beats/min lower in water than land.[37,56,121]

Very few studies have examined energy expenditure in water-based exercise compared to land based forms directly, although knowledge of the acute physiological responses and energy cost of water based exercise is important for safe and effective exercise prescription. One of the first studies to examine the cardiorespiratory and energy expenditure responses to exercise in shallow water compared to land reported higher levels of energy expenditure in water similar heart rates. The authors hypothesized that the effects of water resistance in shallow water while walking and jogging results in high levels of energy expenditure with relatively little strain on the lower extremities, suggesting that this form of exercise may be an effective exercise for individuals with a body weight problem.[34] When exercising in water, there are two factors that influence the cardiorespiratory and energy expenditure response: (a) drag resistance of moving limbs through the water and (b) hydrostatic force supporting body weight in water (buoyancy). When buoyancy is inadequate to provide substantial limb unloading, as is typically seen in water levels below the waist, drag forces imposed by fluid resistance substantially elevate the metabolic cost, as evidenced by the increased VO_2, VCO_2, cost per stride, and heart rate. Conversely, when water depth meets or exceeds waist height, increases in buoyancy counteract a concomitant increase in workload imposed by fluid resistance and metabolic cost declines. One particular study by Alkurdi and colleagues examined the influence of water depth on energy expenditure and included 4 conditions: land, water level to the xiphoid, and water +10cm and -10cm from the level of the xiphoid. Regardless of walking speed, energy expenditure was influenced by water depth reporting significantly greater energy expenditure at -10cm than the other three conditions, including the land condition. Furthermore, water at the level of the xiphoid was significantly greater than the +10cm and Land condition, although the Land and +10 conditions were not significantly different. It was hypothesized that while walking at the xiphoid level, the arms swinging against the resistive drag force of water that likely contributes to similar energy expenditure versus land despite the lower stride cadence.[122] Additionally, the longer the lever and greater girth of the lower extremities increase the forces of hydrodynamic friction, especially turbulence in the water. Turbulence tends to magnify the frictional resistance of water and has been found to increase as the speed of movement increases. Moreover, the lower extremities represent greater muscle mass to lift against the gravitational forces encountered on land.[37] With respect to the upper extremities, Hered et al. compared aquatic exercise using the arms and legs, and legs only, on land and in chest deep water at different intensities, reporting that inclusion of the upper extremities in water based exercise increases the energy cost similar to or greater than responses observed on land.[123] As a result of these influences on energy cost, it has been shown that participants expend between 5.7 and 6.5 kilocalories per minute during various aquatic exercise routines across studies.[124-126] Furthermore, these studies concluded that these aquatic exercise routines can meet the American College of Sports Medicine's guidelines for the improvement of cardiorespiratory fitness, although the guidelines need to be adapted for aquatic training due to some variation in the observed physiological responses.

Finally, the application of the energy expenditure a few studies have investigated the effects of a land based exercise program compared to an aquatics based exercise program, the results are promising. Of the intervention studies that include both a land and water condition, only 3 included overweight but otherwise healthy adults. In all 3 studies, no significant differences were observed between conditions for a wide variety of variables including skinfolds, blood lipids, fitness, body weight, body density, flexibility and strength. However, in all 3 studies, significant improvements were observed for these variables compared to controls or across time indicating that water-based exercise may be a viable alternative to land-based exercise as part of a weight loss intervention.[32,109,127] However, more information is needed regarding the energy cost of water based exercise versus land based exercise in an overweight and obese population.

2.3.2 Additional Benefits of Aquatic Exercise

In overweight and obese individuals, the rationale for recommending regular physical activity to lose weight is that the energy expenditure associated with the activity has the potential to generate a negative energy balance. The use of regular exercise in the treatment of these patients is thus strongly influenced by their ability to exercise. Overweight and obese individuals are typically prescribed land-based activities such as walking that are performed at a moderate intensity due to its practical nature and convenience.[39,40] Despite the proven benefits of aerobic exercise training, these traditional modes of exercise are often associated with increased rick of musculoskeletal injury due to accumulated stress on the lower extremities in individuals with weight problems, although not conclusive.[14,38,41,42,128-130] Furthermore, severely obese individuals, particularly those with a BMI of 40 kg/m^2 and above, may have difficulty performing generally prescribed physical activity, where prolonged weight bearing exercises can cause musculoskeletal problems in individuals with no previous history of joint disease.[41,42] Obesity and overweight are also associated with musculoskeletal pain, as well as with osteoarthritis of the knee and hip.[43-45] Excess body weight is a powerful predictor of the development of osteoarthritis, with every 5kg of weight gain increasing the risk of knee arthritis by 35%.[12] This is most likely due to the 60% greater ground reaction forces at the knee during walking in obese patients than in normal weight patients.[12] Consequently, there is mounting evidence to support that obese individuals have a reduced exercise tolerance, especially when BMI is greater than 40 kg/m^2.[46] Unfortunately, pain and injury from exercise are often cited as reasons for discontinuing exercise training.[131]

To counter the joint injuries and orthopedic problems that often limit exercise in the obese,[132] the American College of Sports Medicine recommends non-weight bearing exercise for physical training in this population.[133] In this regard, aquatic exercise reduces the stress on the lower extremities and spine,[134] and has been recommended for individuals who are overweight and who have orthopedic diseases, such as osteoarthritis.[130] Thus, obese individuals may find water to be a desirable environment for exercise due to the cushioning effect of exercise in water potentially preventing injuries caused by excessive strain on the joints of the lower extremities, experience less heat stress during immersion permitting more efficient heat dissipation due to water's comparatively higher specific heat and thermoregulatory characteristics, and may be perceived as less strenuous.[31,33,35,49]

Furthermore, the net metabolic rate of walking in overweight and obese participants is approximately 10-45% greater than in normal weight individuals.[47,48] This added metabolic cost places them at a greater percentage of their maximum aerobic capacity, making it more difficult to maintain recommended exercise durations. Therefore, the standard prescription of brisk walking for long durations and high frequency, even at a lower intensity (30-50% VO_{2max}), may be perceived as too strenuous.[46] Furthermore, Fujishima reported than at a matched ratings of perceived exertion (RPE), VO_2 and heart rate were higher, indicating that in the water environment, higher physiological workloads may be perceived as easier,[53] although this is not conclusive.[56]

At a physiological level, it is hypothesized that aquatic exercise may be a viable alternative to land-based exercise. However, there are some additional indications that aquatic exercise may be beneficial and/or ideal from a behavioral and psychological perspective in overweight and obese populations. Well understood from previous research, there are many determinants of physical activity participation, both negative and positive. One particular determinant of interest is the strong positive association between enjoyment and overall physical activity.[135] Nagle et al. observed significantly greater enjoyment scores for the group randomized to the aquatic exercise group compared to the land walking group, potentially leading to the observed greater attendance rates.[32] Finally, research has shown that quality of life measures improve in individuals completing an aquatic exercise program, however, only a few of the studies included a control group.[18,19,25] One study in particular included individuals with arthritis, reporting that aquatic exercise had a positive effect on perceived quality of life.[19] Interestingly, the authors further reported that the effect was moderated by BMI such that benefits were observed among obese individuals (BMI >30.0 kg/m^2) but not in overweight or normal weight individuals.

2.3.3 Gender Differences in Aquatic Exercise

Of the 5.8 million Americans participating in aquatic exercise, the majority are women.[136] Due to the increased popularity among females, the majority of more recent shallow water research that has been conducted has focused on female participants. Aside from the preference of females to participate in water-based activity, there are potential gender differences of the physiological responses to aquatic based exercise. In a study by Cassady and colleagues, they reported numerous differences between genders for physiological responses to water and land exercise.[37] Men consistently demonstrated higher VO_2 values in both land and water exercise at various cadences, and women demonstrated greater relative exercise intensity than men did. Furthermore, an interaction was reported between gender and mode, as men consistently demonstrated a greater change in VO_2 than did women, and the gender differences was more pronounced for water exercise than for land exercise. Similarly, a gender x mode interaction was reported for heart rate response, where mean % age predicted maximal heart rate (%APMHR) values showed no significant difference between land and water exercise for men, although women did show a higher % APMHR for land than for water.[37] Finally, it is hypothesized that due to the gender differences in body composition and body fat distribution, the influence of water on buoyancy and drag resistance may differ between men and women.[37] Specifically, it has been shown that women have significantly more adipose tissue, and is distributed lower than in males leading to a lower center of buoyancy, potentially leading to different metabolic responses.[137]

3.0 METHODS

3.1 PARTICIPANTS

A total of 19 apparently healthy participants between the ages of 18-55 were recruited to participate in this study. Only females were recruited to participate in this study due to the potential gender differences for physiological responses to exercise in the water as previously described.[37,137] Participants were also overweight, Class I, Class II, or Class III Obese according to BMI classification (25.0 - <45.0 kg/m^2). Additional exclusionary criteria will be as follows:

1. Height < 154.9cm (61 inches) or > 172.7cm (68 inches). Due to the influence of water depth above the level of the xyphoid process or below the level of the umbilicus on energy expenditure, walking in the pool with a height below or above these levels would be a potential confounder.[50,122]
2. Previous diagnosis of conditions requiring additional medical clearance (i.e. cancer, heart disease, or Type I or Type II diabetes).[133]
3. Presence of a medical condition that may limit one's ability to walk for exercise (i.e. orthopedic limitations or severe arthritis). Participants will be required to walk briskly for exercise to complete the experimental trials, and any orthopedic limitation would limit the ability of the individuals to complete these components.
4. Currently taking prescription or over-the-counter medications that affect heart rate (i.e. anti-depressants, beta-blockers, bronchodilators/antihistamines, calcium channel blockers, digitalis, and thyroid medications).
5. Women who are currently pregnant.

6. Discomfort exercising in shallow water.

3.2 RECRUITMENT AND SCREENING PROCEDURES

Participants were recruited through letters that mailed to individuals meeting eligibility requirements registered in the Obesity and Nutrition Research Center (ONRC) database. Additional recruitment efforts included fliers posted locally, and the use of online recruiting resources (i.e. Craigslist). Interested individuals were instructed to call the University of Pittsburgh Physical Activity and Weight Management Research Center (PAWMRC). They were then read a description of the study and completed a brief phone screening after providing verbal consent (Appendix A). Screening information included questions regarding demographic background, physical health and medical history to determine initial eligibility. Individuals who are found to be eligible following the phone screening were invited to attend an orientation session as described in section 3.3.1. The University of Pittsburgh Institutional Review Board (IRB) approved all recruitment methods and materials, as well as all study procedures prior to the start of the study.

3.3 ORIENTATION AND ASSESSMENT PROCEDURES

3.3.1 Orientation Session

Upon arrival to the University of Pittsburgh, the Principle Investigator reviewed the study protocol and allowed individuals an opportunity to ask any questions before signing an informed consent document. After obtaining written informed consent, participants were asked to complete a Physical Activity Readiness Questionnaire (PAR-Q)[138] to ensure that participation in exercise was not contraindicated (Appendix B). Participants responding in the affirmative to any question on the PAR-Q were not eligible to participate in this study and were instructed to consult with their primary care physical prior to engaging in an exercise program.

Participants then underwent familiarization trials to treadmill walking and shallow water walking using the protocols described below. Participants who were unable to demonstrate that they could perform treadmill walking or shallow water walking were not eligible to participate in this study. Data was not be collected during the orientation practice sessions and was not used to anchor the experimental sessions.

The participants underwent an orientation to the treadmill to practice walking technique, as well as to familiarize them with the equipment. Participants were read a script regarding the proper technique that is required for participation. This also included a checklist of techniques that they needed to demonstrate competency in, including head position, posture, and arm movement, as shown in Appendix C. Participants were then asked to step onto the treadmill set at 2.0 mph and given instruction and feedback on proper walking technique from the research technician. This orientation session lasted $\leq$10 minutes in duration. The participant was then orientated to the equipment by fitting the Cosmed facemask to the participant.

The participants then underwent an orientation to the shallow water to practice shallow water walking technique, as well as to familiarize them with the equipment. Participants were read a script regarding the proper technique required for participation. This also included a checklist of techniques that they needed to demonstrate competency in, including head position, posture, and arm movement, as shown in Appendix D. Participants were then asked to begin walking in the shallow water and given instruction and feedback on proper walking technique from the research technician. This orientation session lasted ≤10 minutes in duration. The participant were then orientated to the equipment by fitting the Aquatrainer to the participant.

3.3.2 Assessment Procedures

The following measures were used to assert eligibility and describe the sample:

1. Height- was measured using a freestanding stadiometer. The participant was instructed to remove their shoes and stand upright with their feet flat on the floor and their back parallel to the vertical scale, looking straight ahead. Duplicate measurements were taken and measurements will be recorded to the nearest 0.1cm. A third measurement will be taken if the two measures differed by ≥1.0 cm. If the criterion is not met after a third measure is taken, the average of the three measures will be used.
2. Body weight and BMI- was be measured using a Tanita digital scale (Tanita Corporation; Arlington Heights, IL). Measurements were made in lightweight exercise clothing with shoes removed. Weight was recorded to the nearest 0.1 kg. BMI was then computed based on measurements of weight and height and was calculated as body weight in kilograms divided by square height in meters (kg/m^2).
3. Body composition- was assessed using a Tanita (Arlington Height, IL) bioelectrical impedance analyzer (BIA). The BIA is a non-invasive pain-free procedure for assessing body composition in which a low-grade electrical impulse is transmitted through the body. The resistance to current flow through tissues reflects the relative amount of body fat present.[139] After height was entered, shoes and socks were removed, and participants

were instructed to stand on the scale instrument for approximately 10 seconds to obtain the body composition assessment (percent body fat).

4. Waist Circumference- A Gulick tape measure was used for obtaining waist girth measurements. Waist circumference were measured horizontally at the iliac crest. To determine the level at which waist circumference were measured the examiner faced the participant and palpate the superior aspect of the pelvis to locate the iliac crest. The participant then placed their fingertips directly above the iliac crest and the examiner placed the measuring tape around the abdomen directly below the fingertips. Duplicate measurements were taken at the end of a normal exhalation, and measurements were recorded to the nearest 0.1cm. A third measurement was taken if the two measures differed by ≥1.0 cm. If the criterion was not met after a third measure is taken, the average of the three measures were used.[140]
5. Hip Circumference- A Gulick tape measure was used for obtaining hip girth measurements. Hip circumference was measured horizontally at the widest part of the hip. To determine the level at which hip circumference was measured the examiner stood at the side of the participant and placed the measuring tape around the hip at the widest part. Duplicate measurements were taken at the end of a normal exhalation, and measurements were recorded to the nearest 0.1cm. A third measurement was taken if the two measures differed by ≥1.0 cm. If the criterion was not met after a third measure is taken, the average of the three measures were used.[140]
6. Thigh Circumference- A Gulick tape measure was used for obtaining thigh circumference. With the participant standing with one foot on a bench so the knee is flexed to 90 degrees, a measure was taken midway between the inguinal crease and the

proximal border of the patella, perpendicular to the long axis. Duplicate measurements were taken, and measurements were recorded to the nearest 0.1cm. A third measurement was taken if the two measures differed by ≥1.0 cm. If the criterion was not met after a third measure is taken, the average of the three measures was used.[140]

7. Leg Length- A Gulick tape measure was used for obtaining leg length measurements. Leg length measurements was measured vertically from the greater trochanter to the base of the lateral malleolus. The participant was instructed to stand comfortably with feet flat on the floor and shoulder width apart. Duplicate measurements were taken, and measurements were recorded to the nearest 0.1cm. A third measurement was taken if the two measures differed by ≥1.0 cm. If the criterion was not met after a third measure is taken, the average of the three measures were used.[140]

8. Physical Activity Level- Current participation in physical activity was assessed using the Global Physical Activity Questionnaire (GPAQ) as shown in Appendix E. GPAQ comprises 19 questions grouped to capture physical activity undertaken in different behavioral domains, these are work, transport and discretionary (also known as leisure or recreation). Within the work and discretionary domains, questions assess the frequency and duration of 2 different categories of activity defined by the energy requirement or intensity (vigorous-or moderate-intensity). In the transport domain, the frequency and duration of all walking and cycling for transport is captured but no attempt is made to differentiate between these activities. One additional item collected time spent in sedentary. This is a valid and reliable measure of physical activity and is reported as METs, and can be broken down into physical activity level classifications (low, moderate, high).[141]

9. Previous Shallow Water and Treadmill Exercise Experience- In addition to collecting information regarding the participants' current physical activity, two questions were included regarding previous experience exercising in shallow water and on a treadmill, as shown in the assessment data collection sheet in Appendix F.

3.4 EXPERIMENTAL DESIGN

The proposed study utilized a crossover design, with participants serving as their own control. Eligible participants reported for three separate experimental trials following the initial orientation and assessment session. These included a shallow water exercise experimental trial and two land exercise experimental trials. Consistent with procedures of similar study protocols, all exercise experimental trials will be separated by at least 48 hours, but no more than 7 days.[37,114,142] Prior to each experimental trial, participants were instructed to refrain from vigorous exercise, and the use of alcohol and tobacco 24 hours prior. Furthermore, participants were instructed to fast for 4 hours prior to the testing sessions. Adherence to the abstention from exercise, tobacco, and alcohol, along with adherence to the 4 hour fast were confirmed by self-report prior to each experimental session (Appendix G).

The experimental trials were partially counterbalanced to reduce testing bias. However, due to the nature of the study design requiring the obtained heart rate response from the shallow water exercise trial to be used during the matched heart-rate response land exercise trial, participants will be randomized to one of three conditions as shown below in Figure 1:

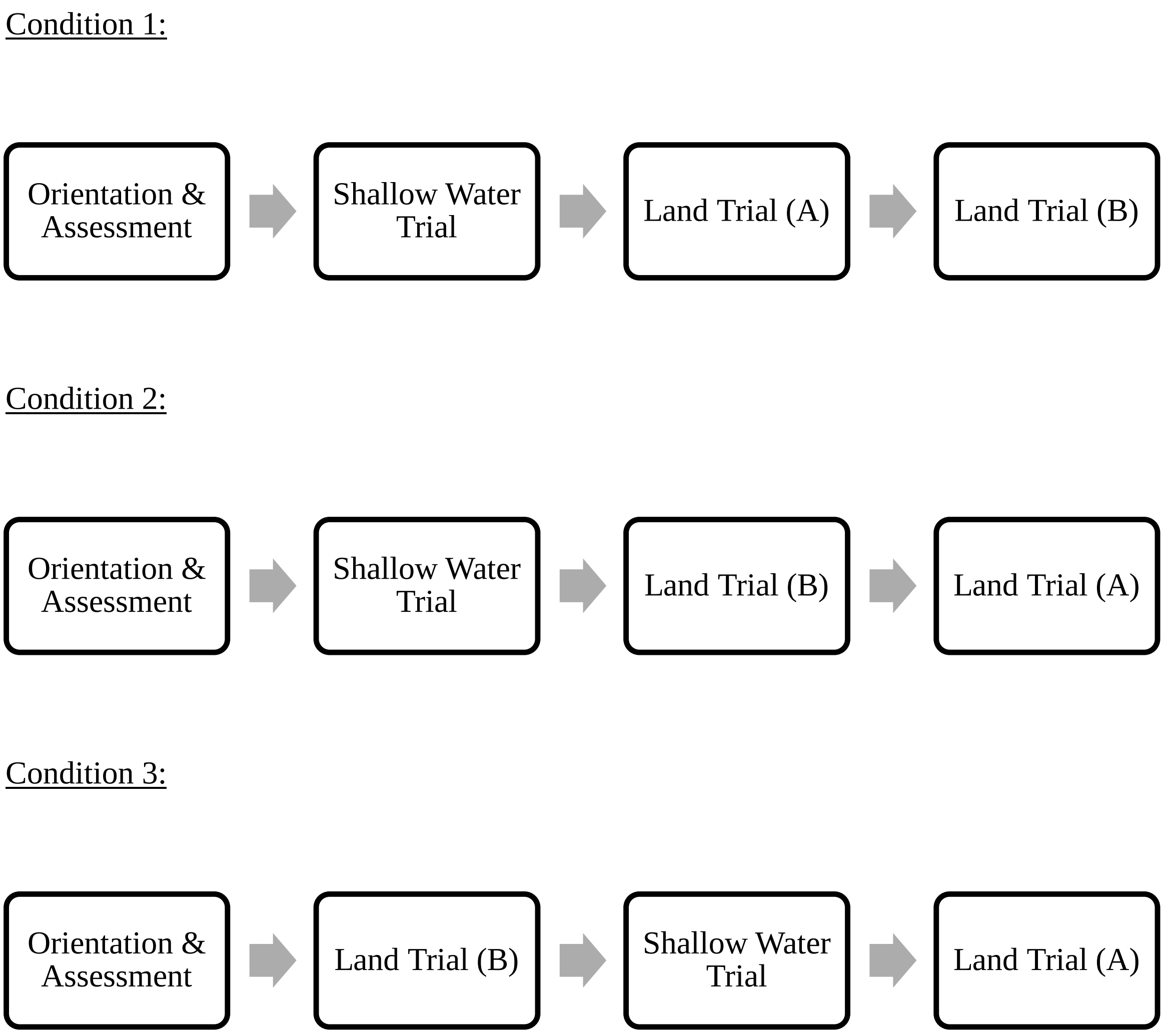

Figure 1. Test Order Conditions

3.5 EXPERIMENTAL TRIALS

3.5.1 Shallow Water Exercise Trial

Prior to the shallow water exercise trial, participants were instructed to wear a traditional tight fitting bathing suit. Loose fitting clothing, such as shorts and t-shirts, were not be permitted during the shallow water exercise trial due to the increased drag forces influence on energy expenditure. Upon arrival, the participant will be fitted with a Polar heart rate monitor, swim cap, water shoes, and Aquatrainer mask. The participant was fitted with the equipment and instructed to sit quietly in a chair for 5 minutes on the pool deck to allow for acclimatization to the equipment. During this time, the participant was given a brief overview of the protocol and the Borg 15-category scale using the script provided in Appendix H.

Participants then completed a 10-minute shallow water-walking bout at a self-selected pace. Participants were instructed to walk at a "comfortable brisk walking pace that can be sustained for 10 minutes." During the initial 5 minutes, the participants were prompted at 30-second intervals to adjust their pace (faster or slower) if they felt it necessary to do so in order to complete the entire 10-minute experimental session. At the 5-minute mark, participants were instructed to maintain their current pace throughout the remainder of the exercise session. The research technician also completed a checklist every minute to determine if the participant was maintaining proper shallow water walking technique (Appendix I). If criteria on the checklist were not met, the research technician corrected the participant. Measures of heart rate, oxygen consumption (VO_2), carbon dioxide production (VCO_2), respiratory exchange ratio (RER), and expired volume (Ve) were obtained continuously each minute. Following the 10-minute exercise bout, the participant was be asked to rate their perceived exertion using the Borg 15-category scale.

To allow the participant to achieve steady state, only the final 5-minutes of the test were used for data analysis. Water temperature was maintained at approximately 27.5◦ Celsius, and testing was rescheduled if the water temperature was below 25◦ Celsius or above 30◦ Celsius, due to the effect of water temperature on energy expenditure outside of this range.[120]

Finally, all shallow water walking bout were recorded using a video camera allowing the researcher to analyze the cadence (steps per minute), speed (meters per second), and distance completed (meters) for descriptive purposes.

3.5.2 Land Exercise Trials

The protocols of the land-based exercise trials are described below. The participant was instructed to wear comfortable exercise clothing and shoes for both land exercise experimental trials.

A. Matched Heart Rate Response Land Exercise Trial- Upon arrival, the participant was fitted with a Polar heart rate monitor and Cosmed facemask. The target heart rate for this trial was determined by averaging the heart rate obtained during the last 5 minutes of the shallow water walking trial. The participant was fitted with the equipment and instructed to sit quietly in a chair for 5 minutes to allow for acclimatization to the equipment. During this time, the participant was given a brief overview of the protocol and the Borg 15-category scale using the script provided in Appendix A. To begin the 10-minute trial, the treadmill was initially set at a speed of 1.0 mph and 0% incline. The participant was then instructed to step on to the treadmill and begin walking. Every 30 seconds, the speed of the treadmill was increased by 0.5 mph until the participant achieved the target heart rate ± 5 bmp. After the initial 5 minutes, adjustments were made to the speed (± 0.1 mph) at 1-minute intervals as needed to maintain the appropriate heart rate range throughout the test. The research technician also completed a checklist every minute to determine if the participant is maintaining proper walking technique (Appendix J). If criteria on the checklist are not met, the research technician corrected the participant. Measures of heart rate, VO_2, VCO_2, RER and Ve were obtained continuously each minute. Following the 10-minute exercise bout, the participant was asked to rate their perceived exertion using the Borg 15-category scale. Furthermore, the speed and incline information on the treadmill display was covered to eliminate any potential influence to the participants efforts or perceived exertion. To allow the participant to achieve steady state, only the final 5-minutes of the test were used for data analysis.

B. Self-Selected Pace Land Exercise Trial- Upon arrival, the participant was fitted with a Polar heart rate monitor and Cosmed facemask. Prior to testing, the participant was fitted with the equipment and asked to sit quietly in a chair for 5 minutes to allow for acclimatization to the equipment. During this time, the participant was given a brief overview of the protocol and the Borg 15-category scale using the script provided in Appendix A. To begin the 10-minute trial, the treadmill was initially set at a speed of 1.0 mph and 0% incline. The participant then stepped on to the treadmill and was instructed to begin walking. During the initial 5 minutes, the participant was instructed to give a hand signal to the research technician at 30 second intervals to increase, decrease, or maintain the speed of the treadmill until they reached their self-selected comfortable brisk walking pace. These adjustments were made at 0.5 mph increments. The speed of the treadmill achieved at 5 minutes was maintained through the remainder of the experimental session. The research technician also completed a checklist every minute to determine if the participant is maintaining proper walking technique (Appendix K). If criteria on the checklist were not met, the research technician corrected the participant. Measures of heart rate, VO_2, VCO_2, RER and Ve were obtained continuously each minute. Following the 10-minute exercise bout, the participant was asked to rate their perceived exertion using the Borg 15-category scale. Furthermore, the speed and incline information on the treadmill display was covered to eliminate any potential bias or influence on the self-selected walking speed. To allow the participant to achieve steady state, only the final 5-minutes of the test were used for data analysis.

3.6 INSTURMENTATION AND PROCEDURES

Indirect Calorimetry: Oxygen consumption (VO_2), carbon dioxide production (VCO_2), respiratory exchange ratio (RER) and expired volume (Ve) were measured during the shallow water walking and land trials using the portable Cosmed K4b^2 metabolic unit and Aquatrainer mask attachment (Chicago, IL), allowing for an in-pool measure of VO_2. The validity and reliability of device have been previously established for land and water use.[143] The Aquatrainer attachment was used during the shallow water walking trial and a facemask attachment was used during the land trials. Previous studies have validated the Aquatrainer attachment to the face mask attachment and have been shown to be highly correlated (R^2= 0.994) for measures of oxygen consumption with a mean difference of ventilatory parameters, including VO_2, VCO_2, and Ve, between the two devices below 1%.[143] Furthermore, non-significant mean absolute differences in VO_2 are approximately 0.9 mL/min when comparing the facemask to the Aquatrainer. Compared to previous models of the Aquatrainer, the new prototype that was used in this study presents some upgrades aiming to reduce gas mixtures, resistances and air turbulence while breathing, by means of a diminished dead space (reduced to 11.3 mL), 2 flexible but not stretchable tubes with larger diameter and shorter length, Hans-Rudolf valves with a larger diameter, and a smooth internal valves assembly surface. In addition, the reduction of the dead space and the use of two supplementary valves tend to reduce mixtures of gases at the valves assembly which might alter the O_2 and CO_2 expiratory fractions. Moreover, to improve comfort during swimming, structural modifications including a soft and oval mouthpiece, a flexible head connection, and flexible but underwater stable tubes were utilized.[143]

To obtain valid and accurate data, standardized turbine (3 L), gas (ambient air with 20.94% O_2 and 0.03% CO_2, and reference gas mixture with 16.0% O_2 and 5.0% CO_2) and delay calibration procedures were performed before each test according to the manufacturer's recommendations. Atmospheric pressure, ambient temperature, and relative humidity will be measured and manually reported to the $K4b^2$ before each test. All data, including heart rate detected by a Polar monitor, were transmitted by telemetry from the Cosmed $K4b^2$ portable unit to a personal computer and controlled in real time. Participants breathed into a fitted mouthpiece with the nose clipped off for the duration of each exercise test. Ve concentrations of O_2 and CO_2 will be analyzed by open circuit spirometry in 15-second intervals. The primary outcome was energy expenditure per minute (kcal/min) of the last 5 minutes of each trial, which was determined from VO_2 (l/min) using the non-protein caloric equivalent (RER) to adjust for energy substrate utilization. Energy expenditure relative to body weight (kcal/min/kg) and the metabolic equivalent (MET) will also be calculated, using the calculation shown below:[144]

Metabolic Equivalent (MET) = VO_2 (ml/kg/min) ÷ 3.5

Heart Rate Monitor: Heart rate (not heart rhythm) was monitored continuously using a Polar heart rate monitor (Port Washington, NY) during all trials.

Ratings of Perceived Exertion (RPE): The Borg 15-category rating scale of perceived exertion was used to measure overall effort and perceived exertion during all trials. Prior to testing, the scale was described to the participant to ensure their understanding using a standardized script shown in

Appendix H. This scale is used by health-fitness professionals to describe the range of indicators that incorporate an individual's perception of physical exertion during exercise.[145]

3.7 STATISTICAL ANALYSES

Statistical analyses were performed using SPSS version 21.0. Statistical significance was set at $p<0.05$. Descriptive analyses were performed for age, height, weight, BMI, waist circumference, hip circumference, thigh girth, leg length, and percent body fat. To examine Specific Aim 1 and 2, separate one-way repeated measures analysis of variance (ANOVA) were performed for the energy expenditure during the last 5 minutes of the exercise trials, and RPE across exercise trials. The assumption of normality was tested using the Shapiro-Wilkes test, and the appropriate nonparametric test was used for all data not meeting the assumption of normality. The assumption of sphericity was confirmed using Mauchly's test. Post-hoc comparisons (dependent t-tests) were made using the Bonferonni adjustment to determine which conditions were significantly different.

3.8 POWER ANALYSIS

Based on an article by Hill and colleagues it was determined that 50 kcal/day could offset weight gain in about 90% of the population.[146] Therefore, 50 kcal/h, or 0.83 kcal/min was determined as a clinically meaningful level of energy expenditure. The results of Alkurdi et al. showed an average standard deviation for energy expenditure at the proposed water depth across conditions of 1 kcal/min, resulting in an effect size of 0.83.[122] The sample size calculation was determined based on the proposed post-hoc analyses using G*Power. It was determined that to detect an effect size of 0.83, with power set at $1-\beta = 0.8$, and the type I error rate set at $p = 0.0167$ using the Bonferonni correction, that 19 participants would be required. When sample size was calculated without the Bonferonni correction, holding all other parameters the same, it was determined that 14 participants would be necessary to detect a significant difference. Therefore, a final sample of 19 participants were recruited to undergo the experimental trials. Based on prior studies, it is anticipated that <10 percent of participants will have incomplete data.

4.0 RESULTS

The purpose of this study was to compare energy expenditure and ratings of perceived exertion during land and shallow water walking in overweight and obese females. This study utilized a randomized cross-over design and the results from the study are presented in the following sections.

4.1 PARTICIPANTS

Telephone screening calls were conducted for a total of 58 individuals. Of these participants, 28 were deemed to be eligible based on the criteria reported previously. Eight of these individuals failed to attend an orientation session, resulting in 20 initially eligible participants. The primary reasons for exclusion were BMI above or below the criteria (N=15) and medications known to effect heart rate (N=8). A total of 20 overweight and obese women attended a study orientation and consented to participate in this study (Figure 2). However, one participant was deemed ineligible at the assessment based on BMI criteria resulting in 19 participants (age 42.11± 10.30 years, BMI 30.92 ± 3.78 kg/m^2) who consented and completed all the experimental sessions.

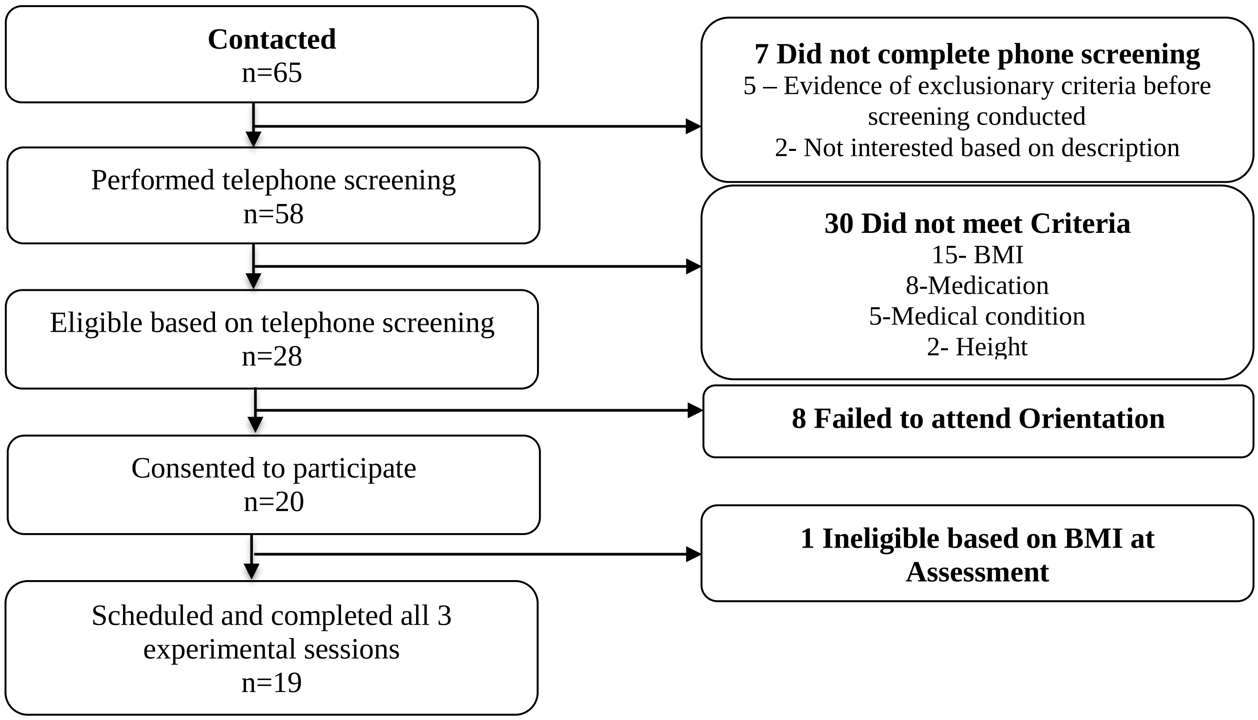

Figure 2. Participant Recruitment and Enrollment

Of the 19 participants, 7 were classified as overweight (BMI = 25.0 to <30.0 kg/m^2), 10 participants were classified as Class I Obese (BMI = 30.0 to <35.0 kg/m^2), 1 participant was classified as Class II Obese (BMI = 35.0 to <40.0 kg/m^2), and 1 participant was classified as Class III Obese (BMI ≥ 40.0 kg/m^2) at the time of the physical assessment. Descriptive statistics (mean ± standard deviation) are shown in Table 1.

Table 1. Participant Descriptive Variables (N=19)

Variable	Mean ± SD	Range
Age (years)	42.11±10.30	21-55
Height (cm)	163.70 ± 4.55	156.10-171.10
Weight (kg)	83.25 ± 13.70	63.30-118.50
BMI (kg/m^2)	30.91 ± 3.78	25.80-40.50
Percent Body Fat	39.54 ± 6.37	26.20-48.50
Waist Circumference (cm)	99.17 ± 9.13	86.05-122.35
Hip Circumference (cm)	112.74 ± 8.16	98.80-133.00
Thigh Circumference (cm)	55.29 ± 5.44	47.75-67.90
Leg Length (cm)	84.08 ± 4.72	75.20-92.00
Waist-to-Hip Ratio (cm)	0.88 ± 0.06	0.76-0.99

Based on the results from the GPAQ, Total MET-minutes/week was not normally distributed, therefore the median was also reported. The participants self-reported a mean of 2346.32 ± 3007.70 MET-minutes/week, and a median of 960 (240, 3120) MET-minutes/week of physical activity. Physical activity level was determined using the classifications recommended by the GPAQ analysis guide and is described below:

HIGH Physical Activity Group:

IF ≥ 3 days of vigorous activity (work and recreational) AND Total physical activity MET-minutes/week ≥ 1500

OR

IF ≥ 7 days of moderate or vigorous activity (work, transportation, recreational) AND Total physical activity MET-minutes/week ≥ 3000

MODERATE Physical Activity Group:

IF ≥ 3 days of vigorous activity (work and recreational) AND Total vigorous minutes/week (work and recreational) ≥ 60
OR

IF ≥ 5 days of moderate activity (work, transportation, recreational) AND Total moderate minutes/week (work, transportation, recreational) ≥ 150

OR

IF ≥ 5 days of moderate or vigorous activity (work, transportation, recreational) AND Total physical activity MET-minutes/week ≥ 600

LOW Physical Activity Group:

IF the value does not reach the criteria for either high or moderate levels of physical activity

The majority of participants were categorized in the Low physical activity group (9; 47.4%), 3 in the Moderate group (15.8%), and 7 in the High group (38.8%). The majority of subjects (57.9%) reported that they were "somewhat" experienced in exercising on a treadmill as well as in shallow water. Self-reported physical activity results are shown in Table 2.

Table 2. Participant Self-Reported Physical Activity Level

Variable	N (%)
Physical Activity Level (GPAQ)*	
Low	9 (47.4)
Moderate	3 (15.8)
High	7 (36.8)
Shallow Water Exercise Experience	
Not At All	2 (10.5)
Somewhat	11 (57.9)
Extremely	6 (31.6)
Treadmill Exercise Experience	
Not At All	1 (5.3)
Somewhat	11 (57.9)
Extremely	7 (36.8)

*Categories based on Analysis Guide provided in Appendix M

4.2 EXPERIMENTAL TRIALS

All participants were able to successfully complete the entire 10 minute bout of walking for each experimental session. Data collected during the last 5 minutes of each exercise trial was averaged and used for analysis. During the matched heart rate response land exercise trial, 3 participants were unable to achieve the target heart rate during the last 5 minutes of the test with two participants falling below and one falling above the target heart rate range. However, when excluded from the primary analyses, the results remained unchanged and were therefore left in the final analysis reported in this section. Analyses both including and excluding these cases are reported in Appendix L. Results for VO_2, heart rate, % of age-predicted maximal heart rate (%APMHR), METS, expired volume, RER, and average walking pace for the experimental sessions are shown in Table 3. Repeated measures ANOVAs showed that there was a significantly lower RER and average walking pace in the shallow water exercise trial compared to both land-based trials, with expired volume also being lower in the shallow water exercise trial compared to the land-based trial matched on heart rate.

Table 3. Experimental Session Results with Post-Hoc Analysis (N= 19)

Variable	**Shallow Water Trial**	**Matched Heart Rate Response Land Trial**	**Self-Selected Pace Land Trial**	***P-Value***
VO_2 (mL/kg/min)	16.28 ± 3.31	18.13 ± 3.96	17.40 ± 4.83	0.077
Heart rate (bpm)	125.25 ± 14.66	125.84 ± 13.80	126.97 ± 15.60	0.860
% age-predicted maximal heart rate	70.67 ± 9.54	71.68 ± 10.0	72.24 ± 11.07	0.825
METS	4.65 ± 0.98	5.18 ± 1.13	4.96 ± 1.36	0.072
Expired Volume (L/min)	37.61 ± 9.91	43.22 ± 10.07	40.39 ± 11.42	0.027
Difference with Shallow Water Exercise Trial	---	-5.61 ± 6.05 *(p = 0.001)*	-2.79 ± 10.23 *(p = 0.251)*	---
Difference with Matched Heart Rate Response Land Exercise Trial	---	---	2.82 ± 9.09 *(p = 0.193)*	---
RER	0.85 ± 0.07	0.90 ± 0.07	0.88 ± 0.07	0.001
Difference with Shallow Water Exercise Trial	---	-0.05 ± 0.06 *(p = 0.001)*	-0.03 ± 0.05 *(p = 0.014)*	---
Difference with Matched Heart Rate Response Land Exercise Trial	---	---	0.01 ± 0.04 *(p = 0.152)*	---
Average walking pace (m/s)	0.58 ± 0.06*	1.48 ± 0.33*	1.45 ± 0.35*	<0.001
Difference with Shallow Water Exercise Trial	---	-0.90 ± 0.29 *(p= 0.00)*	-0.87 ± 0.31 *(p= 0.00)*	---
Difference with Matched Heart Rate Response Land Exercise Trial	---	---	-0.02 ± 0.21 *(p = 0.743)*	---

*Based on N=14 with walking pace for all conditions (shallow water walking pace was unable to be collected for 5 participants).

4.3 ANALYSIS OF DATA BY SPECIFIC AIM

4.3.1 Specific Aim 1: Energy expenditure across exercise conditions

A repeated measures ANOVA demonstrated that energy expenditure (kcals/min) was significantly different between the three experimental sessions (Table 4). Post-hoc analyses revealed a significantly lower energy expenditure in shallow water compared to the matched heart rate response land exercise trial *(p= 0.001).* There was also a trend towards a significantly lower energy expenditure in shallow water compared to the self-selected pace land exercise trial *(p = 0.0192).*

Table 4. Differences in Energy Expenditure (kcal/min) Across Exercise Conditions

	Shallow Water Trial	**Matched Heart Rate Response Land Trial**	**Self-Selected Pace Land Trial**	***P-Value***
Energy Expenditure (kcal/min)	6.46 ± 1.38	7.26 ± 1.29	6.92 ± 1.61	0.046
Difference with Shallow Water Exercise Trial	---	0.80 ± 0.93 *(p = 0.001)**	0.46 ± 1.48 *(p=0.0192)**	---
Difference with Matched Heart Rate Response Land Exercise Trial	---	---	0.34 ± 1.56 *(p = 0.354)**	---

* Critical p-value with Bonferroni adjustment is $p < 0.0167$

4.3.2 Specific Aim 2: Ratings of perceived exertion (RPE) across exercise conditions

A repeated measures ANOVA revealed that RPE was not significantly different between the three experimental sessions (Table 5). Heart rate also showed no significant differences across conditions.

Table 5. Differences in Rating of Perceived Exertion (RPE) and heart rate across exercise conditions

	Shallow Water Trial	**Matched Heart Rate Response Land Trial**	**Self-Selected Pace Land Trial**	***P-Value***
RPE	11.84 ± 1.09	12.21 ± 1.84	11.68 ± 1.60	0.439
Heart Rate (bpm)	125.25 ± 14.66	125.84 ± 13.80	126.97 ± 15.60	0.860

4.4 EXPLORATORY ANALYSIS

4.4.1 Body mass index and energy expenditure differences across exercise conditions

Exploratory analyses were conducted to examine the relationship between BMI and the observed differences in absolute energy expenditure (kcals/min) between shallow water and land walking. Two separate groupings were created as shown below:

1) At or below the median (30.70 kg/m^2); above the median (30.70 kg/m^2)

2) At or below 29.9 kg/m^2 (overweight); at or above 30.0 kg/m^2 (obese)

The results from the two factor repeated measure ANOVA revealed no significant interactions or main effects of BMI on energy expenditure for either of the analyses performed (Table 6).

To account for the influence of body weight on energy expenditure, the exploratory analyses were repeated normalizing energy expenditure for total body weight and expressed as kcal/min/kg. Repeated measures ANOVAs revealed no significant interactions for energy expenditure between BMI groups across conditions (Table 6). However, a main effect was observed for differences between BMI groups split at the median (*p= 0.000*) and between overweight and obese participants (*p= 0.030*).

The analyses were repeated using only the 16 participants that met the heart rate target during the matched heart rate response land exercise trial, and the pattern of the results was similar to those observed when the entire sample (N=19) was included in the analyses (Table 7).

Table 6. Differences in energy expenditure across exercise conditions between BMI groups (N=19)

		Exercise Condition			***p-values***		
Energy Expenditure	BMI Category	**Shallow Water Trial**	**Matched Heart Rate Response Land Trial**	**Self-Selected Pace Land Trial**	***Exercise Condition***	***BMI***	***Condition X BMI***
Absolute Energy Expenditure (kcal/min)	*Below Median (n=10)	6.58 ± 1.60	7.66 ± 1.23	7.37 ± 1.92	0.072	0.222	0.455
	Above Median (n=9)	6.32 ± 1.17	6.8 ± 1.26	6.41 ± 1.05			
	Overweight (n=7)	5.99 ± 1.56	7.48 ±1.46	6.92 ±1.96	0.034	0.838	0.237
	Obese (n= 12)	6.73 ± 1.26	7.13 ± 1.23	6.91 ± 1.46			
Relative Energy Expenditure (kcal/kg/min)	*Below Median (n=10)	0.09 ± 0.02	0.10 ± 0.01	0.09 ± 0.02	0.043	0.000	0.314
	Above Median (n=9)	0.07 ± 0.01	0.07 ± 0.01	0.09 ± 0.02			
	Overweight (n=7)	0.08 ± 0.02	0.11 ± 0.02	0.10 ± 0.03	0.020	0.030	0.103
	Obese (n= 12)	0.08 ± 0.02	0.08 ± 0.02	0.08 ± 0.02			

*Median BMI = 30.70 kg/m^2

Table 7. Differences in energy expenditure across exercise conditions between BMI groups (N=16**)

		Exercise Conditions			***p-values***		
Energy Expenditure	BMI Category	**Shallow Water Trial**	**Matched Heart Rate Response Land Trial**	**Self-Selected Pace Land Trial**	***Exercise Condition***	***BMI***	***Condition X BMI***
Absolute Energy Expenditure (kcal/min)	*Below Median (n=9)	6.36 ±1.54	7.62 ± 6.81	7.05 ± 1.74	0.022	0.282	0.291
	Above Median (n=7)	6.28 ±1.13	6.81 ±1.43	5.98 ± 0.69			
	Overweight (n=7)	6.00 ± 1.56	7.48 ± 1.46	6.92 ± 1.96	0.021	0.829	0.160
	Obese (n=9)	6.58 ± 1.15	7.10 ± 1.37	6.32 ± 1.45			
Relative Energy Expenditure (kcal/kg/min)	*Below Median (n=9)	0.09 ± 0.02	0.10 ± 0.01	0.10 ± 0.02	0.030	0.002	0.253
	Above Median (n=7)	0.07 ± 0.01	0.08 ± 0.01	0.07 ± 0.01			
	Overweight (n=7)	0.08 ± 0.02	0.11 ± 0.02	0.10 ± 0.03	0.021	0.028	0.118
	Obese (n= 9)	0.08 ± 0.01	0.08 ± 0.02	0.07 ± 0.01			

*Median BMI = 30.70 kg/m^2

**3 Participants excluded for not meeting the heart rate target during Matched Heart Response Land Trial

Correlations were also performed to examine the relationship between BMI as a continuous variable and the difference in energy expenditure between shallow water walking and each of the land conditions (Table 8). The difference in absolute energy expenditure was calculated by subtracting the energy expenditure during the land trial from the energy expenditure during the shallow water walking trial (i.e. a positive number would indicate higher levels of energy expenditure during the shallow water walking trial and a negative number would indicate a higher level of energy expenditure during the land trial). The difference in absolute energy expenditure between shallow water and the matched heart rate response land exercise trial was not normally distributed (W= 0.831, $p = 0.022$). The Spearman's coefficients showed a trend toward significance (ρ= 0.413, *p= 0.079*) between BMI and the difference in absolute energy expenditure between shallow water and the matched heart rate response land trial when all participants were included. When the participants not achieving the heart rate target during the matched heart rate response land trial were removed, the correlation achieved statistical significance (ρ= 0.515, *p= 0.041*). Pearson's correlation coefficients were computed for associations between BMI and differences in energy expenditure between shallow water and self-selected land exercise trial, and showed no significant correlation.

Table 8. Correlations between BMI and differences in energy expenditure across exercise conditions.

		Correlation	***P-Value***
Absolute Energy Expenditure (kcal/min)	BMI vs. Difference* in energy expenditure between Shallow Water and Matched Heart Rate Response Land (n = 19) (n = 16)	 ρ= 0.413 ρ= 0.515	 0.079 0.041
	BMI vs. Difference* in energy expenditure between Shallow Water and Self-Selected Land Exercise Trial (n=19)	r= 0.174	0.476
Relative Energy Expenditure (kcal/kg/min)	BMI vs. Difference* in energy expenditure between Shallow Water and Matched Heart Rate Response Land (n = 19) (n = 16)	 ρ= 0.551 r= 0.585	 0.014 0.017
	BMI vs. Difference* in energy expenditure between Shallow Water and Self-Selected Land Exercise Trial (n=19)	r= 0.293	0.224

*Difference in energy expenditure = shallow water- land walking

Correlations were also computed to examine the relationship between BMI and the difference in relative energy expenditure between shallow water walking and each of the land conditions (Table 8). The difference in relative energy expenditure between shallow water and matched heart rate response land exercise trial was not normally distributed (W= 0.824, p = 0.018).

The Spearman's correlations showed a statistically significant correlation (ρ= 0.551; *p= 0.014*) between BMI and the difference in relative energy expenditure between the shallow water and the matched heart rate response land trials. When the participants not achieving the heart rate target during the matched heart rate response land trial were removed, the assumption of normality was met (W= 0.905, p= 0.097) and Pearson's correlation coefficient remained statistically significant (r= 0.585; *p= 0.017*).

4.4.2 Percent body fat and energy expenditure differences across exercise conditions

To examine the relationship between body fat percent and the difference in absolute energy expenditure (kcal/min) between shallow water walking and each of the land conditions, percent body fat was divided into categories at the mean (39.54%). A two factor repeated measure ANOVA was performed, showing no significant interactions (Table 9). The analysis was repeated excluding those who did not achieve the target heart rate during the matched heart rate response land trial, yielding similar results with no significant interactions. However, significant main effects showed differences across exercise conditions (Table 10).

To examine the relationship between percent body fat and the difference in relative energy expenditure between shallow water walking and each of the land conditions, a two factor repeated measure ANOVA was performed, showing no significant interactions (Table 9). However, significant main effects showed differences across exercise conditions and between percent body fat groups. The analysis was repeated excluding those who did not achieve the target heart rate during the matched heart rate response land trial and the relationships remained the same (Table 10).

Table 9. Differences in energy expenditure across conditions between Percent Body Fat groups (N=19)

		Exercise Condition			***p-values***		
Energy Expenditure	Percent Body Fat Category	**Shallow Water Trial**	**Matched Heart Rate Response Land Trial**	**Self-Selected Pace Land Trial**	***Exercise Condition***	***Percent Body Fat***	***Condition X Percent Body Fat***
Absolute Energy Expenditure (kcal/min)	*Below Median (n=9)	6.22 ± 1.46	7.43 ± 1.31	6.85 ± 1.72	*0.059*	*0.884*	0.416
	Above Median (n=10)	6.67 ± 1.35	7.10 ± 1.32	6.98 ± 1.59			
Relative Energy Expenditure (kcal/kg/min)	*Below Median (n=10)	0.09 ± 0.02	0.10 ± 0.02	0.09 ± 0.03	*0.043*	*0.023*	0.276
	Above Median (n=9)	0.07 ± 0.02	0.08 ± 0.02	0.08 ± 0.02			

*Mean Percent Body Fat = 39.54%

Table 10. Differences in energy expenditure across exercise conditions between Percent Body Fat groups (N=16**)

		Exercise Conditions			***p-values***		
Energy Expenditure	Percent Body Fat Category	**Shallow Water Trial**	**Matched Heart Rate Response Land Trial**	**Self-Selected Pace Land Trial**	***Exercise Condition***	***Percent Body Fat***	***Condition X Percent Body Fat***
Absolute Energy Expenditure (kcal/min)	*Below Mean (n=9)	6.22 ± 1.46	7.43 ± 1.31	6.85 ± 1.72	*0.024*	*0.691*	0.398
	Above Mean (n=7)	6.47 ± 1.24	7.04 ± 1.53	6.24 ± 1.04			
Relative Energy Expenditure (kcal/kg/min)	*Below Mean (n=9)	0.09 ± 0.02	0.10 ± 0.02	0.09 ± 0.03	*0.031*	*0.019*	0.338
	Above Mean (n=7)	0.07 ± 0.01	0.08 ± 0.02	0.07 ± 0.02			

*Mean Percent Body Fat = 39.54%

**3 Participants excluded for not meeting the heart rate target during Matched Heart Response Land Trial

Correlations were also performed to examine the relationship between percent body fat as a continuous variable and the difference in absolute energy expenditure between shallow water walking and each of the land conditions (Table 11). Spearman's coefficients were computed for associations with difference in absolute energy expenditure between shallow water and matched heart rate response land exercise trial. Pearson's correlation coefficients were computed for associations with differences in energy expenditure between shallow water and self-selected land exercise trial. The correlations for percent body fat and the difference in absolute energy expenditure between the shallow water and land trials were not statistically significant.

Table 11. Correlations between percent body fat and differences in energy expenditure across exercise conditions.

		Correlation	***P-Value***
Absolute Energy Expenditure (kcal/min)	Body fat % vs. Difference* in energy expenditure between Shallow Water and Matched Heart Rate Response Land (n = 19) (n = 16)	 ρ= 0.420 ρ= 0.450	 0.073 0.080
	Body fat % vs. Difference* in energy expenditure between Shallow Water and Self-Selected Land Exercise Trial (n=19)	r= 0.331	0.167
Relative Energy Expenditure (kcal/kg/min)	Body fat % vs. Difference* in energy expenditure between Shallow Water and Matched Heart Rate Response Land (n = 19) (n = 16)	 ρ=0.556 r= 0.520	 0.013 0.039
	Body fat % vs. Difference* in energy expenditure between Shallow Water and Self-Selected Land Exercise Trial (n=19)	r= 0.405	0.085

*Difference in energy expenditure = shallow water- land walking

Correlations were also performed to examine the relationship between percent body fat as a continuous variable and the difference in relative energy expenditure between shallow water walking and each of the land conditions (Table 11). The differences in relative energy expenditure between shallow water and the matched heart rate response land exercise trial including all subjects did not meet the assumption of normality (W= 0.824, $p = 0.018$). Therefore Spearman's correlation coefficient was used, showing a statistically significant correlation (ρ= 0.556; $p = 0.013$). This relationship remained when the participants who did not meet the target heart rate range were removed from the analysis (r= 0.520; *p= 0.039*). Furthermore, although not statistically significant, there was a trend toward significance between percent body fat and the difference in relative energy expenditure between shallow water and the self-selected pace land trial (r=0.405; *p= 0.085*).

4.5 SUMMARY

In summary, significant differences were shown for energy expenditure between shallow water walking and matched heart rate response land walking. However, when comparing energy expenditure during shallow water walking and self-selected pace land walking, there was a trend towards a lower energy expenditure in shallow water walking, although not statistically significant. Additionally, no significant differences were detected for RPE across exercise conditions. The results of the current study show moderate correlations between measures of body composition (BMI and percent body fat) and differences in energy expenditure between shallow water and land walking.

5.0 DISCUSSION

5.1 SUMMARY OF THE MAIN FINDINGS

The present study is the first to examine and compare energy expenditure in shallow water walking and land walking in a sample of overweight and obese women. The purpose of this study was to compare energy expenditure and ratings of perceived exertion (RPE) during a bout of shallow water walking to a matched heart rate response bout of land walking and a self-selected pace bout of land walking. In the present study, a significant difference of 0.80 ± 0.93 kcal/min was shown for energy expenditure between shallow water walking and matched heart rate response land walking. The difference in energy expenditure during shallow water walking and self-selected pace land walking was 0.46 ± 1.48 kcal/min, which approached statistical significance. Additionally, no significant differences were detected for RPE or heart rate across exercise conditions. Therefore the results of the current study indicate that when physiologically matched based on heart rate, the energy expenditure during shallow water walking is reduced compared to land treadmill walking. When the pace is self-selected, there is a trend towards lower energy expenditure in water compared to on land, although not statistically significant.

5.2 DIFFERENCES IN ENERGY EXPENDITURE BETWEEN SHALLOW WATER AND LAND WALKING

5.2.1 Shallow water walking vs. matched heart rate response land walking

The current investigation showed that absolute energy expenditure (kcals/min) was significantly lower during a bout of shallow water walking when compared to a bout of land walking that was matched based on the heart rate response. Contrary to the study hypothesis, this relationship was opposite the hypothesized direction, and different than that of previously published studies. Previous research suggests that the water environment could potentially allow for high levels of energy expenditure relative to comparable land-based exercise. However, certain methodological differences between previous published studies and the present investigation may explain the differences in the findings including the type of exercise performed in the water and on land, as well as the differences due to the use of an aquatic treadmill.

Darby and Yaekle reported that at a comparable heart rate, performing various exercises in water elicited 2-6 mL/kg/min greater oxygen consumption than when performing similar exercises on land.[116] However, this study used unspecified callisthenic exercises focusing on legs only, as well as arms and legs at various exercise cadence/intensities to evoke comparable relative exercise heart rates on land and in the water for each participant. In contrast, the present study focused on the comparison of walking on land and in the water, requiring forward locomotion and frontal resistance from the water, which could potentially elicit a different metabolic response compared to stationary movement with the added resistance of water.

Another methodological difference between the present study and previously published studies is the differences in walking speed in the water potentially explaining the discrepancies in the findings. Numerous other published studies used an aquatic treadmill with varying speeds, showing higher VO_2 for walking on an aquatic treadmill compared to a treadmill on land.[17,52,54,116-118] For example, Hall and colleagues matched the exercise bouts using walking speed (3.5, 4.5, and 5.5 kph).[52] The results revealed similar VO_2 in water and on land at a slower speed (3.5 kph), but significantly higher VO_2 in the shallow water at 4.5 and 5.5 kph compared to land. Masumoto et al. observed significantly higher VO_2 while walking at a slower speed of 2.4 kph in water versus land.[117] Due to the design of the present study, participants self-selected a walking pace in the water (0.58 ± 0.06 m/sec, converting to approximately 2.0 kph), which was then matched based on heart rate to a bout of land treadmill walking. In comparison to the speed of the aquatic treadmill used in the aforementioned studies, with speeds ranging from 2.4 to 5.5 kph, the participants in the present study were self-selecting a slower walking pace in the water. This may indicate that at slower walking speeds (less than 2.4 kph) the energy cost of walking in water may be less than a land exercise bout when matched on heart rate.

Additionally, the use of an aquatic treadmill reduces the added frontal resistance with forward locomotion when walking through shallow water across a pool floor. It is possible that when using an aquatic treadmill, the reduction of resistance by not moving through the water may allow subjects to walk at higher speeds and elicit higher metabolic responses compared to a speed matched land bout. Gleim and Nicholas[147] reported similar exercise parameters to the present study where subjects walked at a water depth approximately at the level of the umbilicus and at a speed of 40.2 m/min (~0.67 m/sec) on an aquatic treadmill. The results showed that subjects elicited an average relative VO_2 of 8.6 ± 0.4 mL/kg/min.[147] However, the present study demonstrated an average VO_2 of 16.28 ± 3.31 mL/kg/min at a similar water depth and walking speed. From this, it can be hypothesized that the addition of frontal resistance from walking in a pool as opposed to on a stationary aquatic treadmill may add resistance and therefore elicit higher oxygen consumption at similar walking speeds.

Furthermore, studies by Migita et al.[118] and Shono et al.,[17] reported that half the walking speed was required in the water (20, 30, 40 m/min) to achieve the same VO_2 response on land (40, 60, 80 m/min). The current investigation demonstrated similar findings, with participants self-selecting a walking pace in the water slightly less than half the walking speed required to match the heart rate during the land exercise trial (1.38 ± 0.40 m/sec). The present study not designed to confirm this, the current study produced similar VO_2 for the shallow water walking and matched heart rate response land walking conditions, although the shallow water walking speed was less than half that of the land walking speed.

The hypothesis of the current study was primarily based on the existing body of literature, primarily focused on VO_2 and heart rate as primary outcomes. This investigation determined energy expenditure from VO_2 (L/min) using the non-protein caloric equivalent (RER) to adjust for energy substrate utilization. The results of this study showed no significant differences for VO_2 or heart rate between exercise conditions, although a significant difference was detected for RER, with the shallow water trial producing significantly lower RER (0.85 ± 0.07) than the matched heart rate response land trial (0.90 ± 0.07) and the self-selected pace land trial (0.88 ± 0.07). The potential explanations for these differences are twofold. Based on the results of the current study, it is possible that at a similar heart rate, the participants were utilizing different substrate during land walking versus shallow water walking. However, previous studies have not reported RER and we are unable to compare the results of the current study to values of previous studies. It is also unknown if this relationship would persist with any changes to the activity parameters, including duration, and therefore cannot be conclusively stated. Further investigation is warranted to determine if this relationship is consistent across studies with similar as well as longer durations of exercise. If consistent with the current findings, additional research on potential mechanisms and potential implications of the differences in substrate utilization between modes of exercise is warranted.

Additionally, there is a potential that the differences in RER are due to measurement error. As a limitation of the present study, the equipment used for data collection was not identical between water and land. Although the ventilatory parameters, including VO_2, VCO_2, and Ve, have been shown to be highly correlated (R^2= 0.994) between the Aquatrainer and the facemask attachments, slight deviations in VO_2 and/or VCO_2 could explain the difference.[143] Although not reporting RER, a recent validation study reported a mean difference for VO_2 <1% with non-significant mean absolute differences in VO_2 are approximately 0.9 mL/min.[143] However, the mean absolute difference in VCO_2 was approximately 5.1 mL/min, although not a statistically significant difference. Although direct conclusions from these data cannot be made without the reporting of the results for RER, it is possible a slight variation VO_2 and VCO_2 could potentially explain the differences in RER observed in the current study, and therefore the results should be interpreted within this context.

5.2.2 Shallow water walking vs. self-selected pace land walking

One strength of the present study was the inclusion of a self-selected pace land walking trial for additional comparison. Consistent with previously published data regarding self-selected walking paces, the current investigation demonstrated that overweight and obese women self-selecting an average land walking pace of 1.4 m/s. This is similar to that of previously reported walking speeds of normal weight adults (1.4 m/s), although slightly faster than observed walking speeds in obese women with a BMI above 35.0 kg/m^2 (1.2 m/s).[35,148-150] Thus, the results of the present investigation are potentially reflective of the general population.

Of interest, the current investigation showed that absolute energy expenditure was not significantly different during a bout of shallow water walking compared to a bout of land walking at self-selected paces. However, over-interpretation of these results should be cautioned, as the results showed a trend towards significantly lower energy expenditure during shallow water walking compared to the self-selected pace land walking. Although not consistent with the study hypothesis that shallow water walking would elicit higher energy expenditure, the results are a unique and valuable addition to the existing body of literature.

At self-selected walking paces, there are a few potential mechanisms that could contribute to similar energy expenditure in water and on land, including buoyancy and resistance in the water. Previous research suggests that energy expenditure increases directly with increases in body weight on land.[46,151-154] Furthermore, when energy expenditure is normalized for total body mass, the difference between individuals who are obese vs. normal weight is reduced,[48] suggesting that total body weight is a primary determinant of the cost of walking. However, the effects of water buoyancy may result in up to 90% reduction in body weight during walking in shallow water. Despite reduction in weight bearing, VO_2 increases as a function of the relationship between buoyancy and resistance added by the water.[155] When buoyancy is inadequate to provide substantial limb unloading, as is typically seen in water levels below the waist, drag forces imposed by fluid resistance substantially elevate the metabolic cost, as evidenced by similar VO_2 and heart rate.[147,156]

Additionally, the influence of buoyancy is dependent on water depth, and therefore may have a further influence on energy expenditure. Alkurdi and colleagues[122] examined the influence of water depth on energy expenditure of 4 conditions: land, water level to the xiphoid, and water +10cm and -10cm from the level of the xiphoid. Regardless of walking speed, energy expenditure was influenced by water depth reporting significantly greater energy expenditure at -10cm than the other three conditions, including the land condition. Furthermore, water at the level of the xiphoid was significantly greater than the +10cm and Land condition, although the Land and +10 conditions were not significantly different.[122] The current study attempted to control for the influence of water depth by setting a height criteria of 154.9cm (61 inches) to 172.7cm (68 inches), to ensure that that water depth was approximately between the hips and mid axillary. However, it is unknown if this range was appropriate or had an influence on the resultant energy expenditure in water due to differences in buoyancy. Therefore, these factors may have contributed to the energy expenditure in shallow water observed in the current study.[34,35]

The results of the present study provide valuable information regarding the energy cost of walking in water as a potential alternative to walking on land for exercise. In terms of practical application, the comparison of the shallow water walking at a self-selected pace and land treadmill walking at a self-selected pace is highly generalizable, due to the fact that the walking pace and subsequent energy expenditure during these trials most closely reflects that which would be performed in free-living situations. The results of the present study show no statistical difference for energy expenditure or perceived exertion between these trials, although a potentially modest difference may exists for energy expenditure. This may suggest that shallow water walking could be a viable alternative for overweight and obese women, providing similar energy expenditure to land walking.

The American College of Sports Medicine recommends that most adults should engage in moderate-intensity cardiorespiratory exercise training for ≥30 min/day on ≥5 days/week for a total of ≥150 min/week, vigorous-intensity cardiorespiratory exercise training for ≥20 min/day on ≥3 days/week (≥75 min/week), or a combination of moderate- and vigorous-intensity exercise to achieve a total energy expenditure of ≥500-1000 MET-min/week.[157] The results of the current investigation show that during the shallow water walking bout and the land walking bout respectively, participants achieved approximately 71% and 72% of their age-predicted maximal heart rate, 4.7 and 5.0 METs, and 12 on the RPE scale. Based on recommendation set forth by the American College of Sports Medicine (64-76% HR_{max}, 3.0- 5.9 METS, and 12-13 RPE),[157] these parameters for both modes of exercise meet the criteria of moderate intensity exercise. Therefore, shallow water walking can be recommended as a form of exercise for individuals who have access and find aquatic exercise enjoyable without compromising energy expenditure compared to land walking.

5.3 RATINGS OF PERCEIVED EXERTION DIFFERENCES

The results of the present investigation showed that ratings of perceived exertion (RPE) were similar across all exercise conditions, with participants indicating an RPE of ~12 at the conclusion of each experimental session. Although not consistent with the original study hypothesis, the results of the current study are similar to some existing research,[158,159] although the current body of literature is inconsistent.[53,115,158-161] RPE is a valid indicator of exercise intensity on land and in water,[162,163] and integrates information received from peripheral working muscles and joints, from the central cardiovascular and respiratory function, and from the central nervous system.[164]

Some studies have found RPE values to be higher in water when subjects exercised at a pre-selected pace. Byrne et al.[160] and Svedenhag et al.[115] compared water treadmill running with dry land treadmill running and found water RPE ratings to be approximately two units higher than land RPE scores. However, Heberlein et al.[158] and Heithold et al.[159] found no significant difference in RPE ratings between land and water exercise, even though heart rate was significantly higher on land. Fujishima showed in a sample of elderly men that VO_2 was approximately the same during water and land walking trials when anchored to an exercise intensity based on the subjects RPE rating of 13,[53] confirming the earlier work by Takeshima and colleagues, [161] and showing similar results to the current investigation. The present study indicates that when comparing shallow water walking and land walking at similar VO_2 and heart rate, regardless of whether pace was imposed or self-selected, RPE is the same across conditions.

5.4 THE INFLUENCE OF BODY COMPOSITION ON ENERGY EXPENDITURE

The potential influence of body composition on energy expenditure during water exercise is a highly discussed topic in the existing body of literature,[31,33,35,49,114] although rarely studied. Investigators have hypothesized that a higher percentage of body fat will potentially increase buoyancy during water immersion resulting in greater relative energy expenditure at a given workload. This may be due to the additional forces and movements required to counteract the effects of added buoyancy while immersed.[36] The water environment could potentially allow for high levels of energy expenditure relative to comparable land based exercise, although this hypothesis has not been confirmed. Some research has hypothesized that effects of water buoyancy, resulting in up to 90% reduction in body weight, as well as resistance due to the exponentially higher density of water than air make it possible to expend high levels of energy while at the same time reducing strain and impact force on lower extremity joints.[34,35]

Although the present investigation was not designed to do so, exploratory analyses were performed to examine the relationship between body composition and differences in energy expenditure between the different modes of exercise (individual participant data for energy expenditure shown in Appendix N). The results of the present study investigated the relationship in four ways: 1) The relationship between BMI and differences in absolute energy expenditure, 2) the relationship between percent body fat and differences in absolute energy expenditure, 3) the relationship between BMI and differences in relative energy expenditure, and 2) the relationship between percent body fat and differences in relative energy expenditure.

The results of the current investigation show no significant interactions for absolute or relative energy expenditure across conditions and BMI groups or percent body fat group. However, when correlations were performed for differences in absolute energy expenditure between the shallow water walking and matched heart rate response land trials and BMI, a significant correlation was observed. This relationship can be interpreted such that as BMI increases, the difference in energy expenditure between shallow water walking and land walking matched based on the heart rate response decreases, resulting is similar energy expenditures with the difference near zero. Furthermore, when normalized for total body weight, the relationship remained unchanged. Therefore, it can be interpreted that individuals with lower BMI's tend to expend more calories on land compared to in the water. However, at higher BMI's the difference in energy expenditure between land and water is mitigated, showing little difference between the modalities. Further interpretation of the associated scatterplots shown in Appendix O suggests that the difference in energy expenditure approaches zero at higher BMI's, meaning that these individuals are expending a similar number of calories in both exercise modes, whereas individuals of lower BMIs expend more on land compared to water. The present investigation only had two participants classified at Class II Obese or above. It is possible that if this relationship persisted at higher BMI's, these individuals with BMI's greater than 35 kg/m^2, and even more so individuals with BMI's greater than 40 kg/m^2, would exhibit higher levels of energy expenditure in the water compared to land.

The present study also investigated the influence of a more precise measure of body composition, examining the relationship between percent body fat and differences in energy expenditure between shallow water and land walking. The results showed that although differences in absolute energy expenditure were not associated with total percent body fat, when normalized for total body weight, a significant moderate correlation was observed. Similar to the relationship observed for BMI, as percent body fat increases the difference in energy expenditure approaches zero. Therefore, it can be interpreted that individuals with lower percent body fat tend to expend more calories on land compared to in the water. However, at higher percent body fat the difference in energy expenditure between land and water diminishes. Scatterplots shown in Appendix O suggests that the difference in energy expenditure approaches zero at higher percent body fat, meaning that these individuals are expending a similar number of calories in both exercise modes. Interestingly, the scatterplots also show that individuals with the highest percent body fat (>45%) had higher relative energy expenditure in the water than on land, with differences transitioning from negative values indicating higher energy expenditure on land to positive values indicating higher energy expenditure in water. Although the current investigation was not designed to investigate this relationship both due to study design and the limited number of individuals at the higher end of the BMI range and percent body fat range, the results of the current study warrant further investigation.

The present study is the first known study to examine the associations between indicators of body composition and differences in energy expenditure between land and water walking. Previous research has examined associations between BMI and energy expenditure during the activities individually, demonstrating significant correlations between BMI and energy expenditure during water walking at similar water depths. Alkurdi et al. showed that energy expenditure increases while walking on an aquatic treadmill increases with increasing BMI's (slope= 0.3094 $p<0.05$).[122] Similar relationships exist on land, where overweight women exercise at a higher percentage of their peak aerobic capacity (%VO_{2peak}) that their normal weight counter parts both when the intensity was self-selected and when it was imposed or prescribed.[165] The current investigation adds to the existing body of literature, although additional studies are needed to further investigate this relationship, especially in higher BMI (above 40 kg/m^2) and percent body fat (above 45%), as well as other characteristics influencing the differences in energy expenditure between shallow water and land walking.

5.5 STRENGTHS OF THE PRESENT STUDY

The present study is the first to examine and compare energy expenditure between shallow water walking in a pool and land walking in a sample of overweight and obese women. It was designed to address gaps and add to the current body of literature as previously discussed. First, the present study was one of the first studies to examine energy expenditure as a primary outcome. Previous literature has focused on VO_2 and heart rate, without further investigation of the energy cost of the activity compared to land exercise, and its potential as an alternative exercise mode. Furthermore, the present investigation is the only study known by the investigator to examine these relationships in a sample of overweight and obese women. With these strengths in mind, the interpretations of the results of this study are an important addition to the existing body of literature.

5.6 LIMITATIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

There are several limitations to this investigation that may have contributed to the interpretation of the observed outcomes. Therefore, these findings must be considered within the context of these limitations and future investigations should address the following:

1. This study was limited to overweight and obese (25.0-44.9 kg/m^2), apparently healthy women between the ages of 18 and 55 and between 5’1” and 5’8”. Therefore, caution should be used when generalizing these findings to other populations, such as men, normal weight adults, and other special populations.
2. The current study was powered to detect a difference in energy expenditure based on the 3 condition comparison post-hoc analyses, resulting in 19 participants. The necessary sample size was achieved to provide adequate power to answer the specific aims of the proposed study, but was not designed to examine the influence of body composition on differences in energy expenditure discussed in this paper. Future research should be specifically designed and appropriately powered to further explore these aims.

3. The present study did not collect race as a descriptive variable and therefore did not allow for any potential analyses of racial influences. Future studies should include a diverse racial/ethnic population to allow for comparisons of racial/ethnic differences.
4. The present study was based on self-selected pace, as opposed to prescribed intensity, and lacked a measure of fitness. Therefore, we were unable to determine is fitness was associated with energy expenditure in each exercise mode. To examine this relationship and determine the relative intensity of each of the sessions as a percentage of the participants VO_{2peak} or peak heart rate, future investigations should include a graded exercise test in both environments (land and water).
5. The current study used the last 5 minutes of a 10-minute bout of walking for data analysis to allow the subjects to achieve steady state and to reduce participant burden. Future research should consider longer bouts of exercise in addition to the shorter 10-minute bouts to determine if these relationships persist.
6. This investigation recruited individuals with BMI between 25.0 and 44.9 kg/m^2. One particular group of interest included individuals in the Class II and III Obesity category due to the potential that severely obese individuals may have difficulty performing generally prescribed physical activity, with mounting evidence to support that obese individuals have a reduced exercise tolerance.[131] However, the current study only had on participant within Class II and one participant within Class III, making further analysis of the influence of higher BMI's difficult. Future investigations should focus on recruiting more individuals of higher BMI classification to allow for further analysis.

7. The present study used BIA to assess body composition. For future investigations to examine the relationship between body composition and differences in energy expenditure between water and land walking, the use of more accurate body composition measures, such as Dual-Energy X-Ray Absorptiometry (DXA), should be considered.

5.7 CONCLUSIONS

Physical activity is a crucial component of weight management in overweight and obese individuals. With an interest in shallow water walking as an alternative form of exercise,[17] knowledge of the expected physiological responses and estimated energy cost of a given exercise is necessary for the clinician to make decisions on safe and effective exercise programs.[35,37] Although the existing literature is mixed with regards to the energetic profile of water exercise compared to land exercise, the present study is the first to compare a bout of shallow water walking to bouts of land walking in a sample of overweight and obese women. Findings from the current study suggest that although showing a reduced energy expenditure compared to heart rate matched land walking, shallow water walking is a viable alternative to land walking that can elicit and increase in energy expenditure and can be performed at a moderate intensity. While exploratory in nature, we also found an association between measures of body composition and differences in energy expenditure, potentially suggesting that water exercise may be an alternative form of exercise at higher BMI's and percent body fat, with potentially higher energy expenditure compared to individuals with lower BMI's and percent body fat. Due to the limited number of participants with BMI's above 35.0 kg/m^2 (n=2) in the present study, future research should seek to further investigate these relationships in extreme levels of obesity as well as with longer durations of walking.

APPENDIX A

PHONE SCREENING SCRIPT

Shallow Water Exercise Study
Recruitment Form

1. Thank you for your interest in our program. My name is **__________** and I would briefly like to tell you about this research study.
2. **Procedure for Describing the Study and Obtaining Verbal Consent to Conduct the Phone Screen:** A description of the study will be read to the participants, and this description includes important component of the informed consent process (see attached script). Individuals who express an interest in participating in this study will be told the following to obtain verbal consent:
    - **Investigators Component of Informed Consent:** *This study is being conducted by Jacquelyn A. Nagle at the University of Pittsburgh.*
    - **Description Component of Informed Consent:** *The purpose of this study is to examine the energy expenditure in shallow water walking compared to treadmill walking. We are interested in in recruiting 19 healthy females, age 18-55, who are able to walk for exercise in both shallow water and on the treadmill. If you are found to be initially eligible for the study after this phone screening, we will invite you to the laboratory in Trees Hall on the University of Pittsburgh Oakland Campus for an orientation session where the full details of the study will be described to you, you will have a chance to ask questions, and if you are interested in participating, you will be asked to sign a consent document. Next, you will complete an assessment of your height, weight, body fatness, and physical activity level. You will also complete 3 10-minute experimental sessions including a shallow water-walking bout, and 2 sessions on a treadmill similar to a brisk walk.*

      If you are interested in participating in this study, I will need to ask you a few questions about your demographic background and questions about your physical health and medical history to determine you eligibility. It will take approximately 5 minutes to ask you all of the questions. If it we complete the interview, I will ask you for some specific information (i.e. complete name, mailing address, phone number) to contact you regarding your further participation. If you are eligible, you will be invited by mail or telephone to attend an orientation session where all of your questions will be answered in greater detail.

      Your responses to these questions are confidential, and all information related to your health history and current behaviors that you are about to give me will all be destroyed after this interview if you are found to be ineligible. If an answer to a particular questions makes it clear that you are not eligible, I will stop the interview and not ask you any more questions.

      Do you have any questions regarding the information I have provided you? Staff member will answer any questions prior to proceeding, if the individual would like to think about their participation prior to proceeding with the phone screen, they will be provided with the telephone number that they can call if they decide to participate in the future.

- **Voluntary Consent Component of Informed Consent:** *Do you agree that the procedures that will be used to conduct this phone screen have been described to you, all of your questions have been answered, and you give me permission to ask you questions now as a part of the initial phone screen?*
    - If "YES" indicate the participant's agreement with this statement on the top of the next page, sign your name and date the form, and then complete the phone screen. If "NO", thank the individual for calling and <u>do not</u> complete the phone screen.

Phone Screen Interview

The caller give verbal permission to conduct the Phone Screen:

___________YES ___________NO

Verbal Assent was given to:

____

Staff Member Signature

____

Date Verbal Assent was given:

Eligible based on telephone screening: ☐ **Yes** ☐ **No**

If "No", list reason for ineligibility: ____

____

1. **What is your gender?** Male **Female**

2. **How old are you?** **__________ [18-55]**

3. **What is your date of birth** ___/___/___

4. **What is your height?** **________ [5'1"-5'8"]**

5. **What is your body weight?** __________

    a. **Body Mass Index (BMI)** **________ [25.0-44.9]**

6. **Are you able to walk for exercise?** **YES** NO

7. **Has a doctor or other medical persons ever told you that you have any of the following conditions?**
    a. Heart Disease YES **NO**
    b. Angina YES **NO**
    c. Hypertension YES **NO**
    d. Stroke YES **NO**
    e. Heart attack YES **NO**
    f. Diabetes YES **NO**
    g. Cancer YES **NO**

8. **Are you currently be treated by a doctor or other medical persons for any other physical/psychological problems?**

____ YES **NO**

9. **Are you currently taking any prescription medications?** YES NO

Medication	**Used to treat?**

10. **Are you currently pregnant?** YES **NO**

11. **Are you comfortable exercising in shallow water?** **YES** NO

12. **Are you comfortable exercising on the treadmill?** **YES** NO

Contact Tracking Form

THIS PAGE IS COMPLETE ONLY IF THE RESPONDANT APPEARS TO QUALIFY FOR PARTICIPATION IN THIS STUDY

Contact Information:

First Name: ______________________________ Last Name: ______________________________

Street Address: ____

City: ____________________________________ State: ________ Zip code: __________________

Phone Number: __________________________________	Home	Work	Cell
__________________________________	Home	Work	Cell
__________________________________	Home	Work	Cell

OFFICE USE ONLY:

Eligible:	YES	NO
Invited to Orientation:	YES	NO
Orientation Date: ___/___/___		

APPENDIX B

PHYSICAL ACTIVITY READINESS QUESTIONNAIRE

PHYSICAL ACTIVITY READINESS QUESTIONNAIRE (PAR-Q)

PARTICIPANT ID NUMBER: ____________________ ACROSTIC: __________________

DATE: ___/___/______

YES NO

☐ ☐ 1. **Has your doctor ever told you that you have a heart condition <u>and</u> 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 were 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, 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 of <u>any other reason</u> why you should not do physical activity?**

APPENDIX C

TREADMILL ORIENTATION SCRIPT AND CHECKLIST

PARTICIPANT ID NUMBER: **______________________**
ACROSTIC: **_____________________**
DATE: ___/___/______

Treadmill Walking Orientation Script

You will now practice walking on the treadmill. I want you to walk as normal as possible, just as if you are walking outside. As you are walking I want you to focus on standing up straight with your head looking forward. Your arms will be down by your side swinging naturally with each step and your hands will be unclenched, without the assistance of the handrails. Each step that you take should include your entire foot making contact with the treadmill. You will now take the next few minutes and practice the technique I just described and I will correct you if needed.

Start time: ______________________ End time: _____________________

Treadmill Familiarization Trial Checklist

- ❑ Upright posture, not leaning forward
- ❑ Head looking straight forward
- ❑ Arms swinging comfortably at the side
- ❑ Not holding on to handrails of treadmill
- ❑ Steps include a heel strike and toe off

APPENDIX D

SHALLOW WATER ORIENTATION AND CHECKLIST

PARTICIPANT ID NUMBER: ______________________
ACROSTIC: _____________________
DATE: ___/___/______

Shallow Water Walking Orientation Script

You will now practice walking in shallow water. I want you to walk as normal as possible, just as if you are walking on land. As you are walking in the water I want you to focus on standing up straight with your head looking forward. Your arms will be below the surface of the water with your hands relaxed, not clenched and your elbows bent to a 90-degree angle. Your arms will swing naturally just as they would if you were walking on land. Each step that you take should include your entire foot making contact with the ground, and to not walk on your toes. You will now take the next few minutes and practice the technique I just described and I will correct you if needed.

Start time: _____________________ End time: ____________________

Shallow Water Familiarization Trial Checklist

- ❑ Upright posture, not leaning forward
- ❑ Head looking straight forward
- ❑ Arms below the surface of the water
- ❑ Steps include a heel strike and toe off, similar to walking on land; not walking on balls of feet/toes

APPENDIX E

GLOBAL PHYSICAL ACTIVITY QUESTIONNAIRE (GPAQ)

GLOBAL PHYSICAL ACTIVITY QUESTIONNAIRE

PARTICIPANT ID NUMBER: ___________________ ACROSTIC: _________________
DATE: ___/___/______

Physical Activity			
Next I am going to ask you about the time you spend doing different types of physical activity in a typical week. Please answer these questions even if you do not consider yourself to be a physically active person. Think first about the time you spend doing work. Think of work as the things that you have to do such as paid or unpaid work, study/training, household chores, harvesting food/crops, fishing or hunting for food, seeking employment. *[Insert other examples if needed].* In answering the following questions 'vigorous-intensity activities' are activities that require hard physical effort and cause large increases in breathing or heart rate, 'moderate-intensity activities' are activities that require moderate physical effort and cause small increases in breathing or heart rate.			
Questions		**Response**	**Code**
Activity at work			
1	Does your work involve vigorous-intensity activity that causes large increases in breathing or heart rate like *[carrying or lifting heavy loads, digging or construction work]* for at least 10 minutes continuously? *[INSERT EXAMPLES] (USE SHOWCARD)*	Yes 1 No 2 *If No, go to P 4*	P1
2	In a typical week, on how many days do you do vigorous-intensity activities as part of your work?	Number of days └─┘	P2
3	How much time do you spend doing vigorous-intensity activities at work on a typical day?	Hours : minutes └─┴─┘ : └─┴─┘ hrs mins	P3 (a-b)
4	Does your work involve moderate-intensity activity that causes small increases in breathing or heart rate such as brisk walking *[or carrying light loads]* for at least 10 minutes continuously? *[INSERT EXAMPLES] (USE SHOWCARD)*	Yes 1 No 2 *If No, go to P 7*	P4
5	In a typical week, on how many days do you do moderate-intensity activities as part of your work?	Number of days └─┘	P5
6	How much time do you spend doing moderate-intensity activities at work on a typical day?	Hours : minutes └─┴─┘ : └─┴─┘ hrs mins	P6 (a-b)
Travel to and from places			
The next questions exclude the physical activities at work that you have already mentioned. Now I would like to ask you about the usual way you travel to and from places. For example to work, for shopping, to market, to place of worship. [insert other examples if needed]			
7	Do you walk or use a bicycle (*pedal cycle*) for at least 10 minutes continuously to get to and from places?	Yes 1 No 2 *If No, go to P 10*	P7
8	In a typical week, on how many days do you walk or bicycle for at least 10 minutes continuously to get to and from places?	Number of days └─┘	P8
9	How much time do you spend walking or bicycling for travel on a typical day?	Hours : minutes └─┴─┘ : └─┴─┘ hrs mins	P9 (a-b)
Recreational activities			
The next questions exclude the work and transport activities that you have already mentioned. Now I would like to ask you about sports, fitness and recreational activities (leisure), [insert relevant terms].			
10	Do you do any vigorous-intensity sports, fitness or recreational (*leisure*) activities that cause large increases in breathing or heart rate like [*running or football,]* for at least 10 minutes continuously? *[INSERT EXAMPLES] (USE SHOWCARD)*	Yes 1 No 2 *If No, go to P 13*	P10
11	In a typical week, on how many days do you do vigorous-intensity sports, fitness or recreational (*leisure*) activities?	Number of days └─┘	P11
12	How much time do you spend doing vigorous-intensity sports, fitness or recreational activities on a typical day?	Hours : minutes └─┴─┘ : └─┴─┘ hrs mins	P12 (a-b)

Physical Activity (recreational activities) contd.			
Questions		**Response**	**Code**
13	Do you do any moderate-intensity sports, fitness or recreational *(leisure)* activities that causes a small increase in breathing or heart rate such as brisk walking,*(cycling, swimming, volleyball)*for at least 10 minutes continuously? *[INSERT EXAMPLES] (USE SHOWCARD)*	Yes 1 No 2 *If No, go to P16*	P13
14	In a typical week, on how many days do you do moderate-intensity sports, fitness or recreational (*leisure*) activities?	Number of days └─┘	P14
15	How much time do you spend doing moderate-intensity sports, fitness or recreational (*leisure*) activities on a typical day?	Hours : minutes └─┴─┘ : └─┴─┘ hrs mins	P15 (a-b)
Sedentary behaviour			
The following question is about sitting or reclining at work, at home, getting to and from places, or with friends including time spent [sitting at a desk, sitting with friends, travelling in car, bus, train, reading, playing cards or watching television], but do not include time spent sleeping. *[INSERT EXAMPLES] (USE SHOWCARD)*			
16	How much time do you usually spend sitting or reclining on a typical day?	Hours : minutes └─┴─┘ : └─┴─┘ hrs min s	P16 (a-b)

APPENDIX F

ASSESSMENT DATA COLLECTION SHEET

Shallow Water Exercise Study
Assessment Form

ID Number: ______________________ Acrostic: ______________________________

The assessments must be completed in the following order by the individuals listed.

****Mark each item as it is completed.*

- ☐ Greet participant — Initial: _____
- ☐ Height, Weight, BMI Body Composition (BIA) — Initial: _____
- ☐ Waist, Hip, Thigh Circumference — Initial: _____
- ☐ GPAQ — Initial: _____
- ☐ Exercise Experience — Initial: _____

Shallow Water Exercise Study
Assessment Form

ID Number: ______________________________ **Date:** ___/___/___

Acrostic: ______________________________

Height, Weight, BMI, Body Composition

Height: __________ **cm (measure to the nearest 0.1 cm)**

Weight: __________ **kg (read from digital scale to the nearest 0.1 kg)**

BMI: __________ **kg/m^2**

Body Fat%: __________

Circumferences
(Measured in centimeters to 1 decimal point)

	1st Measurement	2nd Measurement	*3rd Measurement
Waist *(level of the iliac crest)*			
Hip *(widest aspect of the hip)*			
Thigh *(midpoint between the inguinal crease and the proximal border of the patella)*			

***Take a third measurement only if the difference between the first and second measurement is > 1.0cm.**

Exercise Experience

1. **How experienced are you exercising in shallow water?**
   Not at all Somewhat Extremely

2. **How experienced are you exercising on a treadmill?**
   Not at all Somewhat Extremely

APPENDIX G

EXPERIMENTAL SESSION COMPLIANCE QUESTIONNAIRE

Experimental Session Compliance Questionnaire

Participant ID: ______________________ Date: ____________ Time: ___________

Session (*circle*): WE Land A Land B

<u>Please ask the participant the following questions:</u>

Have you exercised in the past 24 hours?	☐YES	☐NO
Did you use any tobacco products in the past 24 hours?	☐YES	☐NO
Did you consume alcohol in the past 24 hours?	☐YES	☐NO
Have you consumed anything other than water in the past 4 hours?	☐YES	☐NO

APPENDIX H

BORG 15-CATEGORY RATINGS OF PERCIEVED EXERTION SCALE AND ORIENTATION SCRIPT

6 NO EXERTION AT ALL

7

EXTREMELY LIGHT

8

9 VERY LIGHT

10

11 LIGHT

12

13 SOMEWHAT HARD

14

15 HARD (HEAVY)

16

17 VERY HARD

18

19 EXTREMELY HARD

20 MAXIMAL EXERTION

<u>RPE Definition and Scale Orientation Sheet</u>

Definition of RPE:

We define exertion as the intensity of effort, strain, discomfort or fatigue that you feel during exercise.

Instructions:

While doing physical activity, we want you to rate your perception of exertion. This feeling should reflect how heavy and strenuous the exercise feels to you, combining all sensations and feelings of physical stress, effort, and fatigue. Do not concern yourself with any one factor such as leg pain or shortness of breath, but try to focus on your total feeling of exertion.

Look at the rating scale below while you are engaging in an activity; it ranges from 6 to 20, where 6 means "no exertion at all" and 20 means "maximal exertion." Choose the number from below that best describes your level of exertion. Try to appraise your feeling of exertion as honestly as possible, without thinking about what the actual physical load is. Your own feeling of effort and exertion is important, not how it compares to other people. Look at the scales and the expressions and then give a number.

9 corresponds to "very light" exercise. For a healthy person, it is like walking slowly at his or her own pace for some minutes

13 on the scale is "somewhat hard" exercise, but it still feels OK to continue.

17 "very hard" is very strenuous. A healthy person can still go on, but he or she really has to push him- or herself. It feels very heavy, and the person is very tired.

19 on the scale is an extremely strenuous exercise level. For most people this is the most strenuous exercise they have ever experienced.

Ask the participant the following questions and instruct them to point to the appropriate number on the scale.

1. Rate your feelings of exertion right now.
2. Rate your feelings of exertion when you are running up a moderate hill.
3. Rate your feelings of exertion when you exercised as hard as you can remember.

APPENDIX I

SHALLOW WATER EXPERIMENTAL SESSION DATA COLLECTION SHEET

Shallow Water Walking Trial Instruction Script

You will now walk in the water for 10 minutes at a comfortable brisk walking pace that can be sustained for 10 minutes. During the first 5 minutes, I will prompt you at 30-second intervals to adjust your pace (faster or slower) if you feel it necessary to do so in order to complete the entire 10-minute experimental session. At the 5-minute mark, I will ask you to maintain your current pace throughout the remainder of the exercise session. Every minute I will give you feedback on your walking technique and correct you if necessary. At the end of the 10 minutes of walking, I will ask you to rate your perceived exertion on a scale of 6-20 that was previously described.

Shallow Water Walking Trial Data Collection Sheet

Participant ID Number: ______________________ Acrostic: _____________________

Time	HR	VO_2	RER	Ve	RPE
0:00					
1:00					
2:00					
3:00					
4:00					
5:00					
6:00					
7:00					
8:00					
9:00					
10:00					

Date: ___/___/___ Time: ___: ___ AM/PM

Water Temperature: ____________

Humidity: _____________

Barometric Pressure: ______________

Distance Covered: _____________ yards = ______________ meters

Additional Comments: ____

<u>Shallow Water Walking Experimental Session Technique Checklist</u>

PARTICIPANT ID NUMBER: ________________**ACROSTIC**: ____________________

Date: ___/___/______

1. Upright posture, not leaning forward
2. Head looking straight forward
3. Arms below the surface of the water
4. Steps include a heel strike and toe off, similar to walking on land; not walking on balls of feet/toes

Criteria	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00
1									
2									
3									
4									

APPENDIX J

LAND A EXPERIMENTAL SESSION DATA COLLECTION SHEET

Land A Treadmill Walking Trial Script

You will now walk on the treadmill for 10 minutes at a pre-determined heart rate. During the first 5 minutes, I will be adjusting the speed of the treadmill at 30-second intervals until we achieved the target heart rate. At the 5-minute mark, you will maintain your current pace with adjustments being made every minute to keep you at the appropriate heart rate target. Every minute I will give you feedback on your walking technique and correct you if necessary. At the end of the 10 minutes of walking, I will ask you to rate your perceived exertion on a scale of 6-20 that was previously described.

Land A Treadmill Walking Trial Data Collection Sheet

Participant ID Number: ______________________ Acrostic: _____________________

Time	Speed (mph)	HR	VO_2	RER	Ve	RPE
0:00	1.0					
0:30						
1:00						
1:30						
2:00						
2:30						
3:00						
3:30						
4:00						
4:30						
5:00						
6:00						
7:00						
8:00						
9:00						
10:00						

Date: ___/___/___ Time: ___: ___ AM/PM Target HR: ______________

Air Temperature: ___________Humidity: ____________Barometric Pressure: ______________

Additional Comments: ____

<u>Land Experimental Session Treadmill Walking Technique Checklist</u>

PARTICIPANT ID NUMBER: ______________________**ACROSTIC**: _________________

Date: ___/___/______ **Session:** **Land A** **Land B**

1. Upright posture, not leaning forward

1. Head looking straight forward

2. Arms swinging comfortably at the side

3. Not holding on to handrails of treadmill

4. Steps include a heel strike and toe off

Criteria	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00
1									
2									
3									
4									
5									

APPENDIX K

LAND B EXPERIMENTAL SESSION DATA COLLECTION SHEET

Land B Treadmill Walking Trial Script

You will now walk on the treadmill for 10 minutes at a comfortable brisk walking pace that can be sustained for 10 minutes. During the first 5 minutes, I will prompt you at 30-second intervals to signal to me to increase (with a thumbs up), decrease (with a thumbs down), or maintain (with a closed fist) your pace in order to complete the entire 10-minute experimental session. At the 5-minute mark, you will maintain your current pace throughout the remainder of the exercise session. Every minute I will give you feedback on your walking technique and correct you if necessary. At the end of the 10 minutes of walking, I will ask you to rate your perceived exertion on a scale of 6-20 that was previously described.

Land B Treadmill Walking Trial Data Collection Sheet

PARTICIPANT ID NUMBER: ________________**ACROSTIC**: ____________________

Time	Speed (mph)	HR	VO_2	RER	Ve	RPE
0:00	1.0					
0:30						
1:00						
1:30						
2:00						
2:30						
3:00						
3:30						
4:00						
4:30						
5:00						
6:00						
7:00						
8:00						
9:00						
10:00						

Date: ___/___/___ Time: ___:___ AM/PM Self-Selected Pace: __________mph

Air Temperature: ___________Humidity: ____________Barometric Pressure: ______________

Additional Comments: ____

Land Experimental Session Treadmill Walking Technique Checklist

PARTICIPANT ID NUMBER: ______________________**ACROSTIC**: _________________

Date: ___/___/______ **Session:** **Land A** **Land B**

1. Upright posture, not leaning forward
2. Head looking straight forward
3. Arms swinging comfortably at the side
4. Not holding on to handrails of treadmill
5. Steps include a heel strike and toe off

Criteria	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00
1									
2									
3									
4									
5									

APPENDIX L

DATA ANALYSIS OUTPUTS INCLUDING AND EXCLUDING PARTICIPANTS NOT MEETING HEART RATE CRITERIA

Table 12. Differences in Energy Expenditure (kcal/min) Across Exercise Conditions (N= 16**)

	Shallow Water Trial	**Matched Heart Rate Response Land Trial**	**Self-Selected Pace Land Trial**	***P-Value***
Energy Expenditure (kcal/min)	6.32 ± 1.33	7.26 ± 1.38	6.58 ± 1.45	0.018
Difference with Shallow Water Exercise Trial	---	0.94 ± 0.89 *(p = 0.001)**	0.46 ± 1.48 *(p=0.0192)**	---
Difference with Matched Heart Rate Response Land Exercise Trial	---	---	0.68 ± 1.42 *(p = 0.073)**	---

* Critical p-value with Bonferroni adjustment is $p < 0.0167$
**3 Participants excluded for not meeting the heart rate target during Matched Heart Response Land Trial

Table 13. Differences in RPE Across Exercise Conditions (N= 16**)

	Shallow Water Exercise Trial	**Matched Heart-rate Response Land Exercise Trial**	**Self-Selected Pace Land Exercise Trial**	***P-Value***
RPE	11.94 ± 2.21	12.25 ±1.69	11.81 ± 1.56	0.636

**3 Participants excluded for not meeting the heart rate target during Matched Heart Response Land Trial

APPENDIX M

GPAQ ANALYSIS GUIDE

Levels of Total Physical Activity

Total physical activity MET-minutes/week = the sum of the total MET minutes of activity computed for each setting

Domain	METS value
Work	Moderate MET value = 4.0 Vigorous MET value = 8.0
Transportation	Cycling and walking MET value = 4.0
Recreation	Moderate MET value = 4.0 Vigorous MET value = 8.0

Equation: Total Physical Activity = [(P2 * P3 * 8) + (P5 * P6 * 4) + (P8 * P9 * 4) + (P11 * P12 * 8) + (P14 * P15* 4)]

Level of total physical activity	Physical activity cut off value
High	• IF:(P2 + P11) >= 3 days AND Total physical activity MET minutes per week is >= 1500 **OR** • IF: (P2 + P5 + P8 + P11 + P14) >= 7 days AND total physical activity MET minutes per week is >= 3000
Moderate	• IF: (P2 + P11) >= 3 days AND ((P2 * P3) + (P11 * P12)) >= 60 minutes **OR** • IF: (P5 + P8 + P14) >= 5 days AND ((P5 * P6) + (P8 * P9) + (P14 * P15)>= 150 minutes **OR** • IF: (P2 + P5 + P8 + P11 + P14)>= 5 days AND Total physical activity MET minutes per week >= 600
Low	IF: the value does not reach the criteria for either high or moderate levels of physical activity

APPENDIX N

INDIVIDUAL PARTICIPANT RESULTS

Table 14. Individual Participant Absolute Energy Expenditure Results

			Shallow Water Trial			Matched HR Response Land Trial			Self-Selected Pace Land Trial		
Participant ID	BMI	% Body Fat	kcal/ min	HR	Pace (m/s)	kcal/ min	HR	Pace (m/s)	kcal/ min	HR	Pace (m/s)
001	32.0	44.2	5.85	116.57	missing	6.11	117.81	1.12	6.51	133.75	1.34
002	28.7	31.4	5.36	103.14	0.48	6.25	106.86	1.56	5.07*	112.95	1.34
003	32.7	48.5	7.02	124.14	0.55	6.50*	122.57	1.12	5.07*	missing	1.12
004	25.8	32.3	5.23	142.71	0.59	8.26	142.05	1.79	8.49	137.33	1.79
005	34.1	46.4	7.77	130.6	0.59	7.33*	125.43†	1.30	7.81	missing	1.34
006	27.2	33.6	5.79	112.05	0.63	8.02	115.67	1.76	4.31*	93.05	2.00
007	40.5	46.2	5.19	110.19	0.40	6.28	121.95	0.30	8.07	146.38	0.67
008	30.7	44.4	7.65	139.9	0.51	8.28	137.57†	1.65	8.02	147.81	1.56
009	37.8	47.0	7.71	136.10	0.51	8.95	137.95	1.23	6.05*	132.43	1.12
010	29.0	36.0	9.42	157.76	0.59	9.8	158.24	1.78	9.97	147.90	1.79
011	27.3	34.9	6.1	122.33	0.51	8.11	125.9	1.74	6.02*	missing	1.34
012	30.5	37.1	7.65	132.43	0.59	7.93	133.81	1.78	6.99*	110.50	1.56
013	31.7	43.8	4.94	107.29	0.44	5.15	109.86	0.66	5.23	118.00	0.67
014	32.5	44.0	7.26	143.67	0.48	8.6	145.71	1.54	7.04*	132.00	1.34
015	30.5	41.4	8.51	127.75	missing	8.04*	117.29	1.65	10.23	135.63	1.79
016	26.0	33.3	4.91	117.48	0.48	6.03†	119.76	1.52	7.21	124.76	1.56
017	31.3	41.9	4.83	125.7	0.40	5.72	125.57	1.12	5.78	125.24	1.12
018	31.8	38.6	6.32	124.48	0.51	6.63	122.05	1.34	6.16*	106.67	1.34
019	27.3	26.2	5.17	105.52	0.48	5.88	104.95	1.34	7.39	127.05	1.79

*Shallow Water Energy Expenditure was higher than Land Trial Energy Expenditure
† Individuals not achieving target HR range

APPENDIX O

SCATTERPLOTS FOR SIGNIFICANT CORRELATIONS BETWEEN BODY COMPOSOTION AND DIFFERNCES IN ENERGY EXPENDITURE BETWEEN EXERCISE CONDITIONS

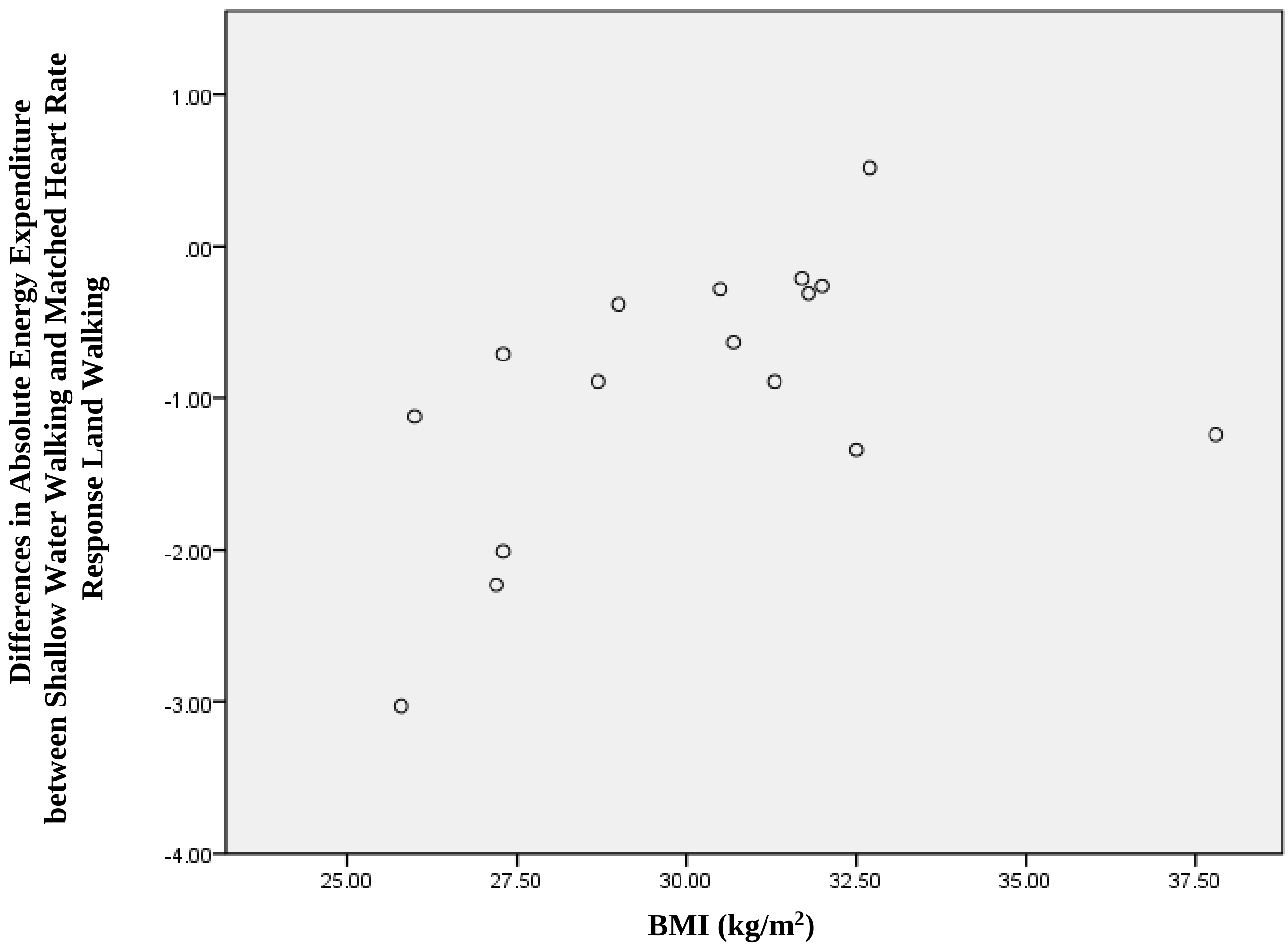

Figure 3. Correlation between BMI and Differences in Absolute Energy Expenditure between Shallow Water Walking and Matched Heart Rate Response Land Walking (N= 16)

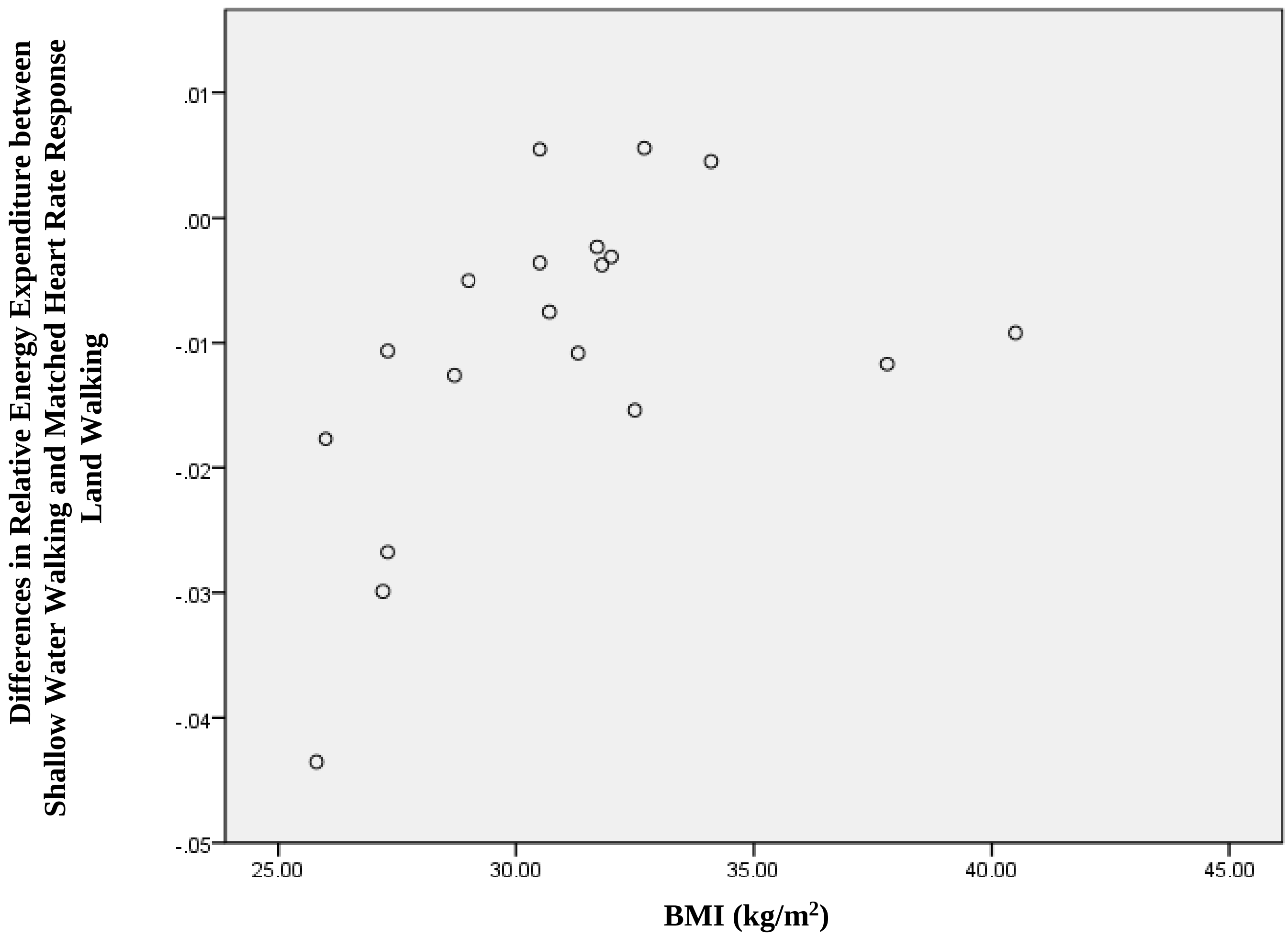

Figure 4. Correlation between BMI and Differences in Relative Energy Expenditure between Shallow Water Walking and Matched Heart Rate Response Land Walking (N= 19)

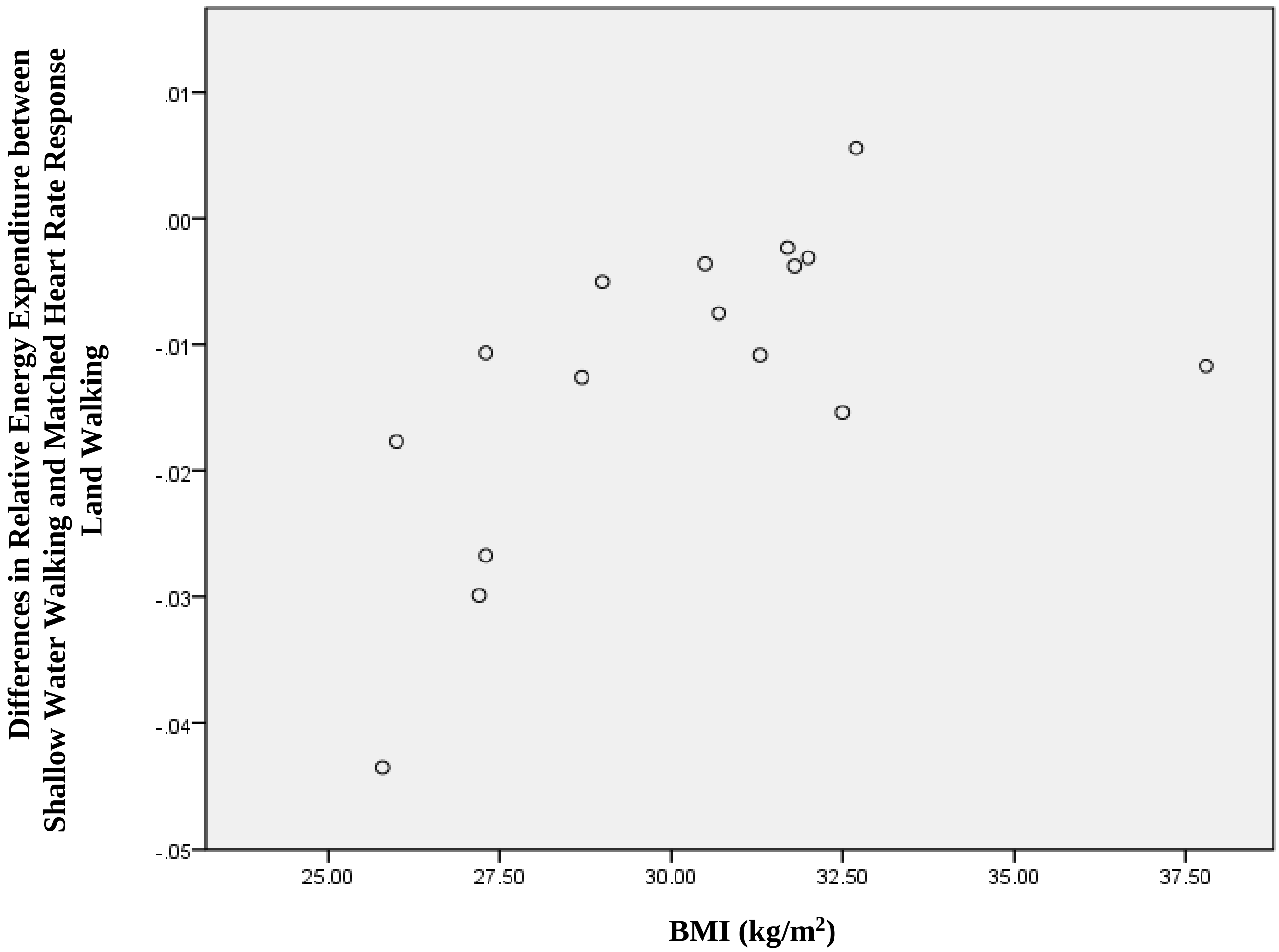

Figure 5. Correlation between BMI and Differences in Relative Energy Expenditure between Shallow Water Walking and Matched Heart Rate Response Land Walking (N= 16)

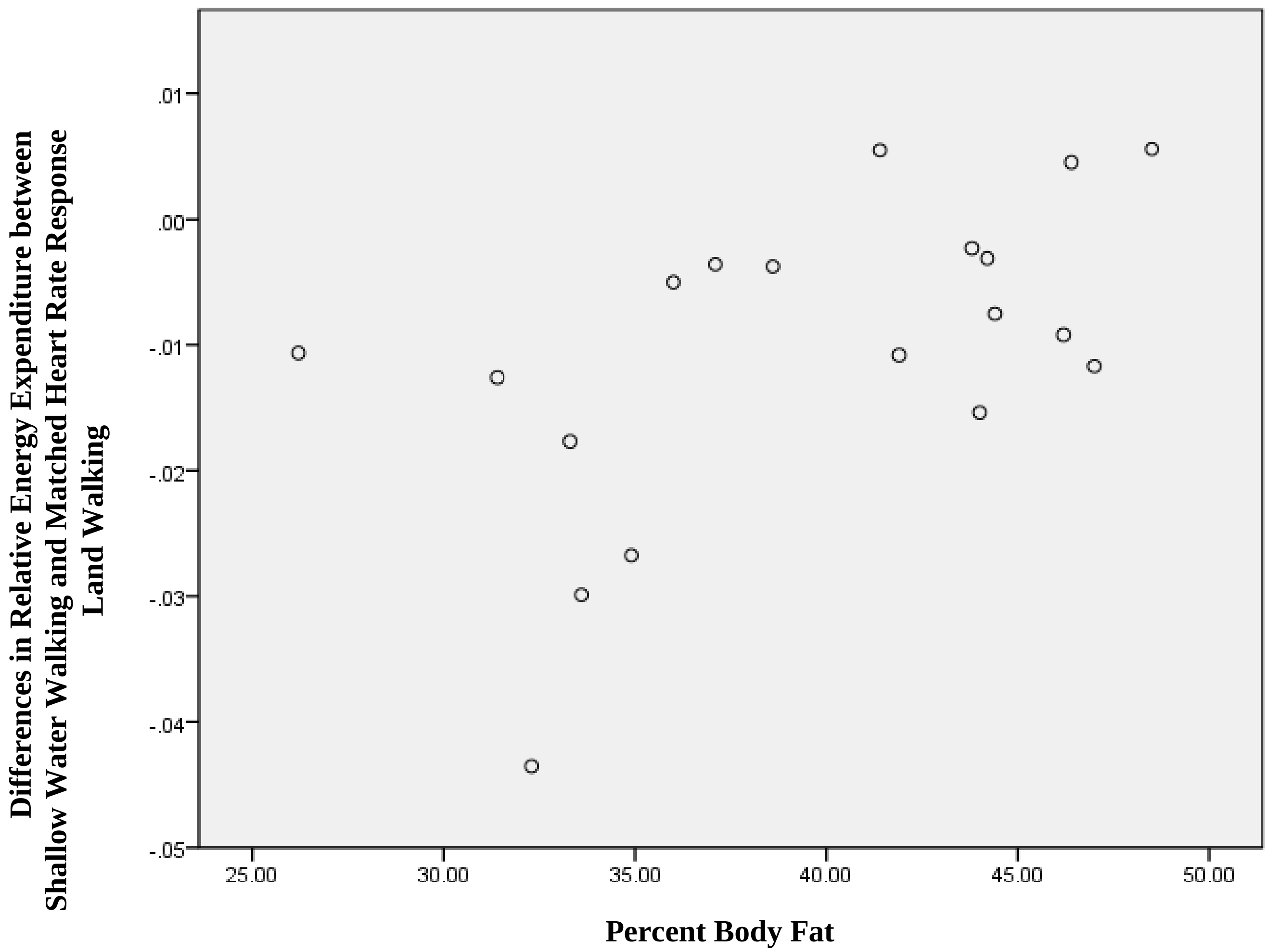

Figure 6. Correlation between Percent Body Fat and Differences in Relative Energy Expenditure between Shallow Water Walking and Matched Heart Rate Response Land Walking (N= 19)

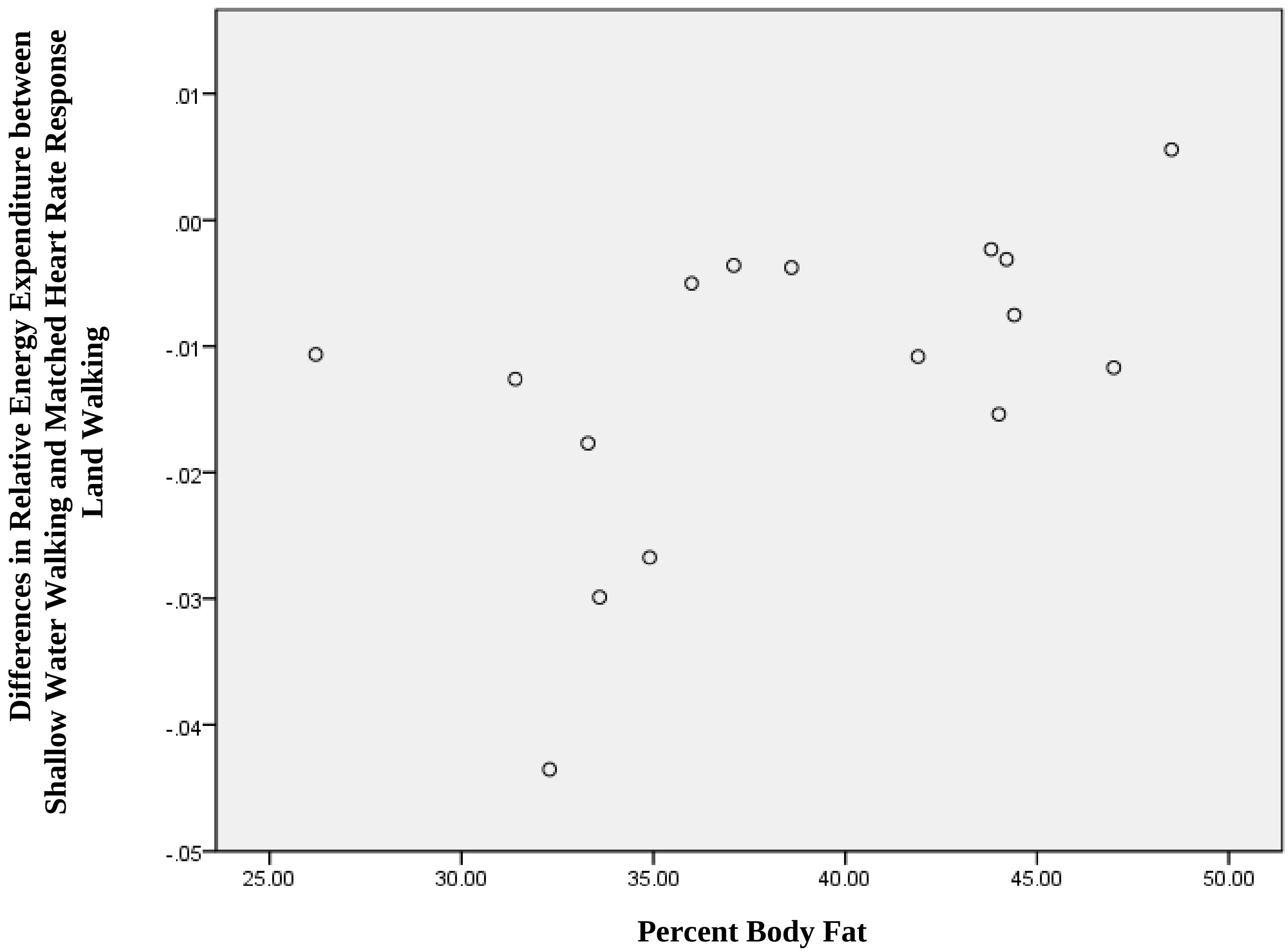

Figure 7. Correlation between Percent Body Fat and Differences in Relative Energy Expenditure between Shallow Water Walking and Matched Heart Rate Response Land Walking (N= 16)

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