CARDIORESPIRATORY RESPONSE DURING EXERCISE ON AN AQUATIC TREADMILL AND LAND TREADMILL IN ADULTS WITH TYPE 2 DIABETES

A THESIS

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BY

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DEDICATION

To my Rocks

My Lord and Savior Jesus Christ: He is all I need.

Mom and Pop: My best can always be better. I love you both unreal amounts

Mother and Daddy: You have given me everything, without you I would not be me. I love you both more than I can express, and I can never thank you enough.

Johnathan, Mika and Myranda: Your love and comic relief keeps me sane. Thank you for everything.

Justin: Thank you so much for all your help through every part of this crazy ride. Now, let’s start our adventure!

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ABSTRACT

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CARDIORESPIRATORY RESPONSE DURING EXERCISE ON AN AQUATIC TREADMILL AND LAND TREADMILL IN ADULTS WITH TYPE 2 DIABETES.

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Purpose: Aquatic treadmill (ATM) exercise may have similar physiologic effects as land treadmill (LTM) exercises. The intent of this study is to compare the effect of the ATM exercise to LTM exercise in people with type 2 diabetes. **Methods:** Participants (n=10) were randomly assigned to two groups. People with Type 2 diabetes were recruited then age and gender matched to a healthy sample. Protocols for both ATM and LTM began at 2 mph with 0% grade and increased by 1 mph after 5 minutes. Termination occurred after participants completed the protocol or reached 85% of heart rate reserve. A 2 x 2 x 3 Mixed Factorial ANOVA and a Bonferroni post hoc was used. **Results:** Heart rate at 2 & 4 mph was significantly different. VO_2 and MAP are similar. **Conclusion:** ATM exercise is an affective mode of exercise for people with type 2 diabetes.

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CHAPTER I

INTRODUCTION

Diabetes Mellitus is a group of metabolic diseases that is defined by the presence of hyperglycemia, also known as an elevated fasting blood glucose level. Hyperglycemia is a result of either defects in insulin secretion or the inability to use insulin (Albright, 2009). Within this classification of metabolic disease, there are four main types. These include type 1, type 2, gestational, and other specific origins. Type 2 diabetes is the most common form, making up 90% of all cases. The cause of type 2 diabetes is insulin resistance with an insulin secretory defect. Insulin is a polypeptide hormone that is produced by the beta cells of the islets of Langerhans of the pancreas, and is used to aid in regulating the metabolism of glucose (Boden, 1994). Like other hormones, insulin has a receptor at target tissues. The receptor transfers phosphate groups from ATP to tyrosine residues on intracellular target proteins. When insulin binds to the alpha subunit, it causes the beta subunit to phosphorylate, activating the catalytic activity of the receptor (Goodyear & Khan, 1998). Insulin facilitates entry of glucose into muscle and adipose tissue, as well as stimulating the liver to store glucose in the form of glycogen. Classification criteria of diabetes by The American College of Sports Medicine (ACSM) is seen in *Table 1*.

Table 1*:*
Glucose Levels in Relation to Classification

Normal	**Prediabetes**	**Diabetes Mellitus**
Fasting plasma glucose <100 mg*dL^{-1} (5.55mmol*L^{-1})	IFG Fasting plasma glucose: 100 mg*dL^{-1} (5.55mmol*L^{-1}) – 125 mg*dL^{-1} (6.49 mmol*L^{-1}) IGT 2-h plasma glucose 140 mg*dL^{-1} (7.77mmol*L^{-1}) – 199 mg*dL^{-1} (11.04 mmol*L^{-1}) during an OGTT	Symptomatic with casual glucose $\geq$200 mg*dL^{1} (5.55mmol*L^{-1}) Fasting plasma glucose $\geq$126 mg*dL^{1} (6.99 mmol*L^{-1}) 2-h plasma glucose $\geq$200 mg*dL^{1} (11.1 mmol*L^{-1})

Note: IFG= Impaired fasting glucose; IGT= Impaired glucose tolerance; OGTT= Oral glucose tolerance test

The prevalence for type 2 diabetes has been increasing for years, and is increasing as people are shifting from a hunter/gather and manual labor lifestyle into a sedentary state. (Fox et al., 2006). According to the American Diabetes Association, from 2010 to 2012 individuals with diabetes in the United States increased from 25.8 million to 29.1 million. Thus, there is a need to investigate the prevention and treatment of type 2 diabetes.

There is an inverse relationship between physical activity and cardiovascular disease, hypertension, stroke, osteoporosis, depression, obesity, colon cancer, breast cancer, anxiety, and type 2 diabetes (Barnes & Schoenborn, 2012; Liu, Goodman, Nolan, Lacombe, and Thomas, 2012; Pescatello, Fargo, Leach, and Scherzer, 2011; Sato, Origuchi, Yamamoto, Takanaga, and Mohri, 2012). The American College of Sports Medicine recommends 150 minutes of moderate to vigorous aerobic activity, and weight training 3 - 5 days per week for healthy individuals. For individuals with type 2 diabetes, a minimum of 150 minutes per week of moderate aerobic exercise, or 60 to 75 minutes of vigorous activity per exercise session is recommended. It is suggested to avoid having more than two consecutive days between bouts of activity. Resistance exercise for individuals with type 2 diabetes, at moderate (50% of 1RM) or vigorous (75% to 80% of 1RM) intensity, is recommended two to three times per week, but never on consecutive days (Albright, 2009; ACSM, 2013).

Land treadmill exercise (LTM) has been used as a mode of aerobic exercise for decades. Physiological improvements have been seen not only through the aerobic stress that is placed on the body, but also by the mechanical stress placed on the lower limbs (Anliker & Toigo, 2012). These loads on the body may elicit an increased cardiovascular endurance, decreased fat mass, and improved lower extremity bone mineral density (Chang, Huang, Huang, Chen, & Cheng, 2010).

Aquatic treadmill (ATM) exercise has commonly been used for rehabilitation purposes, or as an alternative mode of exercise for individuals that suffer from bone, joint or gait issues. Most recent ATM research has been targeted to better understand the physiological response ATM exercise elicits in healthy populations (Silvers et al., 2007; Choukroun, Kays, and Verène 2011; Conners, Morgan, Fuller, and Caputo, 2014). Although ATM research is scarce, research involving the profound effect of water immersion of the human body is abundant (Becker, 1994; Eldrich, 1987; Hall, Bisson and O'Hare, 1990; Johnson, 1994; Saunders & Kennedy 1998; Greene, Lambert, Greene, Carbuhn, Green, and Crouse, 2009).

Water exerts 22.4 milliliters of mercury (mmHg) of hydrostatic pressure for every foot of vertical immersion (Eldrich, 1987; Jasinskas, 2014). The average healthy adult systolic blood pressure (SBP) is 120 mmHg, while diastolic blood pressure (DBP) is 80 mmHg (ACSM,2013). Therefore, if an individual is standing vertically in 4 feet of water, the pressure exerted on their feet is approximately 89.6 mmHg. This exceeds the average value for DBP. Water depth and lower extremity pressure have a positive correlation, meaning the higher the water, the greater the pressure on the lower extremities. If the water level reaches over the shoulder, less blood will reach the lower extremities and instead will remain close to the thoracic cavity. This will increase central blood volume, increasing venous return, and thus increasing stroke volume indicative of the Frank-Starling Law (Pappano & Wier, 2012). Heart rate will in turn decrease aiming to maintain similar cardiac output as experienced before water immersion (Albright, 2009; Pappano & Wier, 2012).

Problem Statement

ATM exercise elicits similar exercise responses as its LTM counterpart (Greene, Lambert, Greene, Carbuhn, Green, and Crouse, 2009). However, it is unclear if ATM exercise will elicit similar physiological responses as seen in traditional modes of exercise in individuals with type 2 diabetes. Further investigation may lead to development of exercise prescription that includes ATM training for this special population. The purpose of this study is to evaluate the effects of ATM exercise verses the effects of LTM exercise on individuals with type 2 diabetes and healthy individuals.

Hypotheses

H_O : There will be no effect of group on heart rate, VO_2, or MAP.

H_O : There will be no effect of mode on heart rate, VO_2, or MAP.

H_O : There will be no effect of speed on heart rate, VO_2, or MAP.

H_O : There will be no effect of the interaction of group and mode on heart rate, VO_2, or MAP.

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Significance

Aquatic treadmill exercise is an attractive alternative to conventional LTM exercise due to the benefits that an aquatic environment can provide. These benefits include: 1) buoyancy, which decreases stress on the joints; 2) resistance supplied by the water; 3) hydrostatic pressure, which assists with venous return, and; 4) relaxation, which improves blood flow. Using water as a medium may lead to improved physiological function in those with type 2 diabetes, particularly if cardiovascular or musculoskeletal comorbidities exist. However, there is very limited research that exists regarding the effect of ATM exercise in those with type 2 diabetes. In fact, there has only been one study in which the effect of ATM exercise was investigated in individuals with type 2 diabetes. Our purpose was to compare the effect of ATM exercise and LTM exercise in individuals with type 2 diabetes. Results were compared to healthy individuals that participated in the same protocols. This is the first study in which common fitness parameters were measured and compared between those with type 2 diabetes and those without type 2 diabetes on an ATM and on an LTM at varying speeds. The results from the present study contribute to our understanding regarding the efficacy of the effects of the ATM as a mode of exercise to improve fitness and quality of life in those with type 2 diabetes.

CHAPTER II

LITERATURE REVIEW

Aerobic and resistance training are vital for maintaining a healthy lifestyle. For those with metabolic diseases (e.g., type 2 diabetes), exercise can have a substantial impact on symptom progression and quality of life (Marwick et al., 2009). Church et al. (2010) conducted a study investigating the benefits of aerobic training, resistance training, and a combination of the two on hemoglobin A_{1c} (HbA_{1c}) concentration in individuals with type 2 diabetes. In this study, 262 sedentary individuals with type 2 diabetes that had HbA_{1c} levels of 6.5% or higher were enrolled in a 9-month training program. Groups consisted of a non-exercise control (n=41), a group that performed resistance exercise only three days per week (n=73), a group that performed aerobic exercise only expending 12 kcal/kg per week (n=72), and a group that combined aerobic training expending 10 kcal/kg per week with resistance training performed twice per week (n=76). Aerobic exercise modes included a standard exercise prescription based on ACSM's suggested 150 minutes per week at moderate intensity (ACSM, 2013). Resistance training consisted of: two sets of bench press, a seated row, a shoulder press, and a lat pull down; three sets of leg press, and; two sets of abdominal crunches and back extension. Each set consisted of 10 to 12 repetitions. The participants in the combination group completed all aerobic and resistance exercises. Only one set of each resistance exercise modality was performed. The authors found that a combination of aerobic and resistance exercise improved HbA_{1c} concentration when compared to the non-exercise control group. The mean change between these two groups was -0.34%. When compared to the control group, those who only performed aerobic exercise or only performed resistance exercise also improved their HbA_{1c} concentrations. However, the magnitude of change in HbA_{1c} concentration was not as great (i.e., -0.24% change for the aerobic only group and -0.16% change for the resistance only group). The authors concluded that while aerobic or resistance training has health benefits, a combination of the two modalities may elicit greater physiological responses (Church et al., 2010).

Ronald et al. (2007) also conducted a study investigating the effects of aerobic exercise, resistance exercise and combination of the two modes on glycemic control in people with type 2 diabetes. Once screened for inclusion, the participants were split into four groups: a sedentary control, an aerobic only group, a resistance only group, and a combined aerobic and resistance group. The participants were enrolled in a training program for 22 weeks and exercised three times per week. The aerobic training group exercised on either an LTM or bicycle ergometer while wearing heart rate monitors. Heart rate was monitored between 60% of 75% of age-predicted maximal heart rate. The resistance training group completed seven sets of exercises on machines targeting all major muscle groups. The combined group completed the full aerobic and resistance training protocols. Changes in HbA_{1c} concentration, plasma lipid concentrations, body composition, plasma lipid volumes and blood pressure were measured. After the training session, blood pressure and plasma lipid volumes were not found to be significantly different among the groups. However, HbA_{1c} concentration and body composition were found to be significantly different when all training groups were compared to the sedentary control group. The combined aerobic and resistance training group had the greatest HbA_{1c} concentration difference (-0.38%) when compared to the control group. The authors concluded that aerobic and resistance training alone may improve glycemic control, but the magnitude of improvement is greater when the exercise modalities are combined (Ronald et al., 2007).

Aerobic and resistance exercise training may therefore be more effective at treating symptoms when combined in those with type 2 diabetes. Modes of exercise include aerobic training on a treadmill, elliptical, or cycle ergometer followed by a resistance training protocol that includes exercises that target different muscle groups. One mode of exercise, aquatic exercise, utilizes both aerobic and anaerobic training concurrently. Aquatic running has been investigated in multiple variations, including deep water running (DWR) and shallow water running (SWR). The objectives of many of these previous research studies include the investigation of numerous physiological effects while running on a treadmill in an aquatic setting versus running on a treadmill in a land setting (Migita et al., 1996).

Deep water running (DWR) is a popular mode of aquatic exercise. DWR is performed by providing the participant with a floatation belt that prevents the head and neck from being submerged in the water. The preferable depth is 12 feet, but any depth that ensures the participants do not contact the bottom of the pool throughout the exercise is suitable. The participants may be tethered to the side of the pool or allowed to move about freely, mimicking the gait that is utilized during LTM exercise while being submerged in deep water (Silvers, Rutledge, and Donly, 2007). However, a different kinematic gait pattern is associated with DWR and lower extremity muscle recruitment contrasts to that of LTM exercise (Kamiko et al., 2003). Additionally, a lower VO_{2peak} and a lower heart rate have been recorded during DWR when compared to LTM exercise (Lim & Rhi, 2014). These differences may be attributed to hydrostatic pressure, which can lead to an increased thoracic pressure and thus a lower heart rate (Lim & Rhi, 2014). Another mode of aquatic exercise is shallow water running (SWR), which is completed in shallow water with the water depth typically at or below the xiphoid process. There are two main modes of SWR. One mode employs the use of a water jet that provides resistance while exercising. The other mode of SWR involves exercising on an aquatic treadmill (Chewning, 2011).

Silvers et al. (2007) investigated cardiorespiratory responses during maximal effort on an ATM and an LTM. A jet resistance system was used with a water temperature of 28°C during exercise on the ATM. Twenty-three recreational male and female runners volunteered for the study. The protocol for the LTM exercise began at 6.3 mph and 0% grade. The speed was increased by 0.5 mph every 4 to 5 minutes, with a grade increase of 2% every minute, until fatigue. The ATM protocol began at 6.1 mph and increased by 0.5 mph every 4 to 5 minutes. The resistance of the jets was increased by 10% every minute. Heart rate, VO_2, V_E, and RER were sampled continuously during testing. A significant difference was only found with V_E. In summary, SWR on an ATM can elicit similar peak cardiorespiratory responses during maximal exertion when compared to LTM exercise (Silvers et al., 2007).

The use of the treadmill as a therapy tool in an aquatic setting has been the focus of other studies (Fujishima & Shimizu, 2003). The effects of buoyancy in ATM exercises was recently investigated by Kamiko et al. (2011). The authors noted that buoyancy reduces the stress of gravity on the joints during high intensity exercise. Aquatic exercises may therefore be a better alternative for those who are particularly affected by high impact exercise (Kamiko et al., 2011). In another study completed with elderly women, investigators found that when the water level is maintained below the xiphoid process, the resistance provided by the water was greater when compared to the magnitude of buoyancy. The difference was even greater when the water level was below the waist (e.g., mid-thigh). Independent of water level, a greater magnitude of resistance and energy expenditure was observed with ATM versus LTM exercise (Shono, Fujishima, Hotta, Ogaki, & Masumoto, 2001). In another study, a middle-aged male underwent an exercise protocol on both an LTM and an ATM. The authors found that, in order to obtain similar levels of cardiovascular stress, the speed of the LTM exercise needed to be doubled relative to ATM exercise (Migita et al., 1996).

When matched for speed and incline, participant exertion during ATM exercise contrasts with that of LTM exercise. In a study conducted by Lim and Rhi (2014), nine healthy college students completed a bout of walking for 30 minutes at 3.7 mph on an LTM and 30 minutes of walking at 1.9 mph on an ATM, the order which was randomized. The speeds were selected in order to maintain the ATM exercise at one-half of the speed of the LTM exercise. The gradient of both treadmills was kept at 0%. Water temperature was maintained between 30°C and 31°C, while the laboratory temperature was maintained between 23°C and 25°C. The depth of water while on the ATM was maintained inferior to the xiphoid process and superior to the navel. Throughout the exercise bout, VO_2, VCO_2, V_E and RPE were measured every 10 seconds and heart rate was measured every five minutes. Blood samples were collected for the concentration analysis of lactate and epinephrine before and after the exercise bout. Energy expenditure was calculated by using the following formula:

$$\text{Energy expenditure} = VO_2 \times (3.9 + 1.1 \times \text{RER}) \text{ (kcal/min)}$$

Heart rate, RPE, energy expenditure, blood lactate, and epinephrine concentrations were significantly increased with both LTM and ATM exercise. Although the heart rate response was significantly lower in ATM than LTM exercise, RPE, energy expenditure, blood lactate, and epinephrine concentrations were not significantly different between LTM and ATM exercise. The authors concluded that half the speed is needed on the ATM to elicit similar physiological stress when compared to exercise on the LTM (Lim & Rhi, 2014).

Water temperature is an important variable to consider when exercising on an ATM. Thermoneutral environments are 21°C to 22°C in air and 34°C to 35°C in water (Chewning, 2011). A high ambient temperature while exercising on an LTM can result in cardiovascular drift. This phenomenon may be attributed to the rush of skin blood flow that cools the body while increasing heart rate to maintain cardiac output (Pappano & Wier, 2012). Nakamitsu et al. (1994) recorded an increase in cardiac work, (i.e., the product of stroke volume, aortic pressure and heart rate) of 80% and a reduction in total peripheral resistance with temperatures of 32°C. Inversely, a colder environment may cause peripheral vasoconstriction (Nakamitsu et al., 1994).

Convection, or the loss of heat by the movement of fluids, is observed with exercise in water. Water therefore cools the body faster than air. Choukroun et al. (2011) measured cardiovascular dynamics while participants were immersed in chest-deep water of varying temperatures. In a thermoneutral condition (34°C), cardiac output was increased slightly, though heart rate decreased significantly. The same result was observed in the colder water (25°C), though the decrease in heart rate was not as great. A decrease in vital capacity and maximum breathing capacity paralleled a decrease in water temperatures of 25°C, 34°C and 40°C (Choukroun, Kays, Verene, 2011).

Water depth is another important factor to consider when exercising in an aquatic environment. Gleim and Nicholas (1989) completed a study comparing an LTM protocol to a similar protocol using an ATM. Significantly elevated VO_2 and heart rate was observed with ATM exercise at ankle, below-knee, mid-thigh, and waist depth when compared to LTM exercise at $\geq$ 2 mph. At speeds ≥ 5 mph, VO_2 during ATM exercise was not significantly greater than VO_2 during LTM exercise. However, heart rate was significantly lower on the ATM compared to the LTM (Gleim & Nicholas, 1989). Although there are numerous studies that evaluate ATM exercise, little research exists that includes individuals with type 2 diabetes exercising on an ATM.

Only one known study has investigated the effects of ATM exercise in those with type 2 diabetes. In this study, the effects of 8 weeks of ATM training on glycemic control and other health related fitness markers in adults with type 2 diabetes were examined (Conners, Morgan, Fuller, and Caputo, 2014). Pre and post HbA_{1c} concentrations, body composition, heart rate, estimated aerobic capacity, and concentric torque of the quadriceps and hamstrings were measured. Before and after the intervention, maximal aerobic power was estimated using an LTM protocol. The participants included seven adults, both male and female, ranging from 47 to 63 years of age. During the exercise protocol, the water level was set at 10 cm below the xiphoid process. Participants completed three ATM exercise sessions per week with one day of rest between each session. Water temperature was maintained at 29°C to 30°C. The exercise included three walking bouts that were separated by a 5-minute seated session on a flotation device inside of the therapy pool. The intensity protocol gradually increased each week starting at 40% to 50% heart rate reserve (HRR) and ending at 50% to 70% of HRR. The investigators found a decrease in HbA_{1c} concentration, body composition, and resting heart rate. Estimated aerobic capacity, peak hamstring torque and peak quadricep torque were higher. These results lead the authors to conclude that ATM exercise is effective in terms of improving glycemic control and other health related fitness aspects in adults with type 2 diabetes (Conners et al, 2014).

The positive cardiovascular and metabolic effects of a combined aerobic and resistance training program is evidenced in both healthy populations and in those with type 2 diabetes. Specifically, combined aerobic and resistance exercise increases aerobic capacity, decreases resting heart rate, improves blood pressure, and improves glycemic control. ATM exercise in a thermoneutral environment is a mode that allows for simultaneous aerobic and resistance exercise to occur. As observed in individuals with type 2 diabetes, the use of ATM exercise has been seen to elicit positive health related fitness aspects. It is for this reason that the effects of ATM training on people with type 2 diabetes should be investigated.

CHAPTER III

METHODOLOGY

Participants

Two groups were used for this study. The first group (n= 5) comprised of individuals with type 2 diabetes between 40 and 80 years of age. Men and women were allowed to participate without regard to fitness level. The second group (n= 5) comprised of healthy individuals matched according to the age and gender of the diabetic group. Additional criteria for both groups included height allowing for water level to be between xiphoid process and umbilicus, being void of orthopedic problems that are aggravated by exercise, and signs or symptoms of cardiovascular, pulmonary, or metabolic disease. Participants must also have been free of a previous surgical procedure within the last six months and be comfortable in an aquatic setting. Medication that was being taken was not altered for the study, but noted in the results.

Procedures

Preliminary Visit

Once inclusion was established at the preliminary visit, the participants read over the IRB approved and stamped informed consent form that introduced them to the procedures. After they had read the informed consent, a researcher provided a verbal overview of the procedures. If the participants had any questions at that time, they were answered to insure complete understanding before a signature was acquired and initial measures taken. Age, height, weight, percent body fat, and blood pressure were then recorded.

Height was measured using a standiometer (Perspective Enterprises, Kalamazoo, MI). Weight was recorded on a BWB-800 scale (Tanita, Arlington Heights, Il). Both were used in calibration of the respiratory analysis equipment.

A seven-site skin fold measurement was used to measure body fat percentage. The sites measured included the: abdominal, triceps, biceps, chest/pectoral, medial calf, midaxillary, subscapular, suprailiac, and thigh. For men, the following formula taken from ACSM's 9th edition was used to determine body density (BD):

BD = 1.112 – 0.00043499*(sum of seven skinfolds) + 0.00000055*(sum of seven skin folds)^2 – 0.00028826*(age in yrs)

For women BD was determined by the following ACSM (2013) formula:

BD = 1.097 – 0.00046971*(sum of seven skinfolds) + 0.00000056*(sum of seven skinfolds)^2 – 0.00012828*(age in yrs)

Percent body fat was then calculated using the BD calculation:

% fat = (495/ Body Density) - 450

A sphygmomanometer and stethoscope were used to measure blood pressure at the brachial artery of the left arm. Participants remained seated quietly for at least 5 minutes in a chair with back support, and feet flat on the floor with arms supported at heart level. The blood pressure classification scale provided by ACSM was used to evaluate inclusion and exclusion criteria for the participants in the exercise protocol (See *Table 2*). Individuals with a resting blood pressure greater than Stage 1 values were excluded from the study.

Table 2:

ACSM Blood Pressure Classification

Category	Systolic (mmHg)	Diastolic (mmHg)
Normal	<120	And<80
Prehypertension	120 – 139	Or 80 – 89
Stage 1 Hypertension	140 – 159	Or 90 – 99
Stage 2 Hypertension	≥160	Or ≥100

Note: All values are in units of mmHg (ACSM, 2013)

The participants were given a participant number and randomly assigned to perform ATM exercise first (Group 1) or perform LTM exercise first (Group 2). Group 1 took part in the ATM, then moved to the LTM. Group 2 took part in the LTM then proceeded to the ATM (see *Table 3*). Dates and times for future testing were then scheduled. Individual privacy desires, personal schedule, schedule of lifeguards, and availability at one time of day for multiple days were taken into consideration when scheduling.

Table 3:

Process of Testing Protocol in Both Groups.

	Group 1	Group 2
First visit	• Complete Informed Consent • Screen for inclusion • Schedule next two visits	• Complete Informed Consent • Screen for inclusion • Schedule next two visits
Second Visit	• ATM protocol • Rest 15 minutes • ATM protocol	• LTM protocol • Rest 15 minutes • LTM protocol
Third Visit	• LTM protocol • Rest 15 minutes • LTM protocol	• ATM protocol • Rest 15 minutes • ATM protocol

Testing Session

Experimental procedures were reviewed prior to testing, and verbal confirmation was obtained to ensure agreement of consent. There were 4 to 7 days between the two different exercise modes.

A heart rate monitor (Polar INC., Lake Success, NY) was fitted to each participant before each exercise session. The participants were then fit with a mask covering the mouth and nose that was attached to a headgear to secure it in place during the exercise protocol. Proper mask size was assessed to confirm a suitable fit. The mask was connected to a respiratory gas analyzer (Cosmed $K4b^2$, Rome, Italy) via a tube attached to the front of the mask. After the equipment had been properly fitted to the participant, a 5-minute seated resting period began. Blood pressure was collected at the end of this rest period. Heart rate and respiratory gasses were measured throughout the rest period.

Aquatic treadmill session. Participants were required to wear swimming attire that abided to the rules set in place by the pool management at TWU. Water shoes were not permitted. The ATM that used was an AquaGaiter (Hudson Aquatic Systems LLC, Angola, IN) for all participants. The treadmill allowed for a variance in speed ranging from 0.5 mph to 5.0 mph with no possibility of incline. Therefore, the participants' height ensured the water level remained at or below the xiphoid process and above the umbilicus.

When taking part in the ATM session, an acclimation to water temperature was allowed before a resting heart rate and blood pressure were measured. Participants straddled the treadmill while it was brought to speed. A warm-up was performed at 2 mph and 0% grade for 5 minutes. The test increased the speed by 1 mph with no change in grade every 5 minutes. The test was terminated when the participant had completed a 5-minute stage at 5 mph or had reached 85% of their heart rate reserve, whichever occurred first. During the testing protocol, relative VO_2 (ml/kg/min) and absolute VO_2 (L/min), were collected using a breath-by-breath analysis. After the protocol, the data was averaged over one-minute intervals for further analysis. Blood pressure (mmHg) was collected the last 60 seconds of each stage. Mean arterial pressure (MAP) was calculated using the following formula:

MAP = 1/3 (SBP - DBP) + DPB

Heart rate was recorded every minute and evaluated every 30 seconds once the participant was within 60% of their age predicted heart rate using the heart rate monitor. Participants completed the protocol, rested for approximately 15 minutes, and then repeated the protocol.

Land treadmill session. Exercise on the LTM was performed in the same manner as exercise on the ATM. An LTM (Cardiac Science®, Marcy, NY) was used for all participants. To maintain validity of data, the same LTM was used for all participants. *Table 4* illustrates the protocol to be followed on both the LTM and the ATM.

Table 4:

The Land Treadmill and the Aquatic Treadmill Protocols

Stage	Time (minutes)	Speed (mph)	Grade (%)
1	5	2	0
2	5	3	0
3	5	4	0
4	5	5	0

Statistical Analysis

The dependent variables included: relative VO_2 (ml/kg/min) and absolute VO_2 (L/min), heart rate (BPM), and mean arterial pressure (MAP; measured in mmHg). The independent variables included group (individuals with type 2 diabetes and healthy individuals), speed (2mph, 3mph, and 4mph), and exercise modes (LTM or ATM). Data for each mode was averaged for individual participants to represent one trial. A 2 x 2 x 3 Mixed Factorial ANOVA was used to investigate significant difference ($p<.0125$) in SPSS v. 22 (International Business Machines, Armonk, NY), along with a Bonferroni post hoc.

CHAPTER IV

RESULTS

Participants for this study included both males (n=2) and females (n=8). Participants with type 2 diabetes had an average age of 51 $\pm$ 6 years while the healthy participants had an average age of 51 $\pm$ 6 years Descriptors such as height, weight, and percent body fat were initially measured and recorded and are listed in Table 5 and Table 6.

Table 5:

Descriptive Measures for Participants with Type 2 Diabetes

Individuals with Type 2 Diabetes	Sex	Age (yrs)	Height (cm)	Weight (kg)	Percent Body Fat (%)
1	F	45	165	117	32.7
2	F	54	169	112	33.6
3	F	58	172	69	28.2
4	F	54	163	72	32.7
5	M	45	182	111	30.6
Mean		51	170	96	31.6
SD		6	7	24	2.2

Table 6:

Descriptive Measures for Healthy Participants

Control	Sex	Age (yrs)	Height (cm)	Weight (kg)	Percent Body Fat (%)
6	F	46	167	59	18.7
7	F	55	172	73	29.9
8	F	59	170	68	28.3
9	F	51	163	61	29
10	M	46	179	96	28.5
Mean		51	170	71	26.8
SD		6	6	15	4.6

The analysis of the effect of group on heart rate, relative VO_2, absolute VO_2, and MAP at 2, 3 and 4 mph is displayed in Table 7. A significant difference between individuals with type 2 diabetes and healthy individuals in MAP was noted ($p<.0125$). Individuals with type 2 diabetes had an MAP of 96 $\pm$ 4 mmHg and the healthy controls had a lower MAP of 84 $\pm$ 8 mmHg.

Table 7:

Means and Standard Deviations of Group on Heart Rate, Relative and Absolute VO_2, and Mean Arterial Pressure

	Group	Mean $\pm$ SD	p-value
Heart Rate (bpm)	T2DM	113 $\pm$ 12	.158
	Control	102 $\pm$ 11	
Relative VO_2 (ml/kg/min)	T2DM	12.0 $\pm$ 2.5	.063
	Control	14.7 $\pm$ 1.8	
Absolute VO_2 (L/min)	T2DM	1.16 $\pm$ 0.39	.421
	Control	1.00 $\pm$ 0.27	
Mean Arterial Pressure (mmHg)	T2DM	96 $\pm$ 4	.012*
	Control	84 $\pm$ 8	

Note: *=significant difference; VO_2=oxygen consumption; T2DM=Type 2 Diabetes Mellitus

Heart rate values between LTM and ATM exercise can be found in Table 8. Heart rate between LTM and ATM exercise was significantly different ($p<.0125$) with land having a higher mean (112 $\pm$ 14 bpm) than water (102 $\pm$ 11 bpm). Relative and absolute VO_2 and MAP were not significantly different between land and water.

Table 8:

Means and Standard Deviations of Mode on Heart Rate, Relative and Absolute VO_2, and Mean Arterial Pressure

	Mode	Mean $\pm$ SD	p-value
Heart Rate (bpm)	LTM	112 $\pm$ 14	.001*
	ATM	102 $\pm$ 11	
Relative VO_2 (ml/kg/min)	LTM	12.5 $\pm$ 1.5	.413
	ATM	13.6 $\pm$ 3.3	
Absolute VO_2 (L/min)	LTM	1.04 $\pm$ 0.29	.513
	ATM	1.12 $\pm$ 0.37	
Mean Arterial Pressure (mmHg)	LTM	90 $\pm$ 8	.766
	ATM	89 $\pm$ 9	

Note: *=significant difference; LTM=Land treadmill; ATM=Aquatic treadmill; VO_2=oxygen consumption

The increasing speeds of the exercise protocol elicited increasing effects of heart rate, relative and absolute VO_2, and MAP. All speeds were significantly different (Table 9*).* Mean values increased with speed for all categories.

Table 9:

Means and Standard Deviations of Speed on Heart Rate, Relative and Absolute VO_2, and Mean Arterial Pressure

	Speed (mph)	Mean $\pm$ SD	p-value
Heart Rate (bpm)	2	91 $\pm$ 11	<.001$^{*+\alpha}$
	3	105 $\pm$ 12	
	4	125 $\pm$ 15	
Relative VO_2 (ml/kg/min)	2	9.4 $\pm$ 1.5	<.001$^{*+\alpha}$
	3	13.0 $\pm$ 2.3	
	4	16.7 $\pm$ 3.5	
Absolute VO_2 (L/min)	2	0.77 $\pm$ 0.23	<.001$^{*+\alpha}$
	3	1.08 $\pm$ 0.33	
	4	1.38 $\pm$ 0.43	
Mean Arterial Pressure (mmHg)	2	87 $\pm$ 8	<.001$^{*+\alpha}$
	3	90 $\pm$ 8	
	4	93 $\pm$ 9	

Note: *=significant difference between 2 and 3 mph; $^{+}$= significant difference between 3 and 4 mph; $^{\alpha}$= significant difference between 2 and 4 mph

VO_2=oxygen consumption

There was a significant effect of group and mode on relative VO_2 and MAP. There were no other significant effects. Individuals with type 2 diabetes and their age and gender matches had similar heart rate and absolute VO_2.

Table 10:

Means and Standard Deviations of Mode and Group on Heart Rate, Relative and Absolute VO_2, and Mean Arterial Pressure

	Mode	Group	Mean $\pm$ SD	p-value
Heart Rate (bpm)	LTM	T2DM	118 $\pm$ 15	.166
		Control	105 $\pm$ 11	
	ATM	T2DM	107 $\pm$ 10	.164
		Control	98 $\pm$ 10	
Relative VO_2 (ml/kg/min)	LTM	T2DM	11.5 $\pm$ 1.1	.003*
		Control	13.6 $\pm$ 0.7	
	ATM	T2DM	12.6 $\pm$ 3.9	.375
		Control	14.6 $\pm$ 2.8	
Absolute VO_2 (L/min)	LTM	T2DM	1.11 $\pm$ 0.36	.385
		Control	0.96 $\pm$ 0.21	
	ATM	T2DM	1.19 $\pm$ 0.42	.573
		Control	1.05 $\pm$ 0.34	
Mean Arterial Pressure (mmHg)	LTM	T2DM	96 $\pm$ 4	.012*
		Control	84 $\pm$ 7	
	ATM	T2DM	95 $\pm$ 3	.023
		Control	83 $\pm$ 9	

Note: *=significant difference LTM=Land treadmill; ATM=Aquatic treadmill;

VO_2=oxygen consumption; T2DM=Type 2 Diabetes Mellitus

No significant difference was noted in heart rate (Table 11), relative VO_2 (Table 12), or absolute VO_2 (Table 13), which compare group and speed for both LTM and ATM exercise. Although the values increased with an increase in speed, there was no difference between the two groups at each speed for heart rate, relative $VO_{2,}$ absolute $VO_{2,}$.

Table 11:

Means and Standard Deviations of Speed and Group on Heart Rate

	Speed (mph)	Group	Mean $\pm$ SD	p-value
Heart Rate (bpm)	2	T2DM	96 $\pm$ 10	.124
		Control	86 $\pm$ 10	
	3	T2DM	110 $\pm$ 12	.169
		Control	99 $\pm$ 10	
	4	T2DM	132 $\pm$ 15	.193
		Control	119 $\pm$ 13	

Note: T2DM=Type 2 Diabetes Mellitus

Table 12:

Means and Standard Deviations of Speed and Group on Relative VO_2

	Speed (mph)	Group	Mean $\pm$ SD	p-value
Relative VO_2 (ml/kg/min)	2	T2DM	8.8 $\pm$ 1.6	.107
		Control	10.1 $\pm$ 1.1	
	3	T2DM	12.2 $\pm$ 2.7	.128
		Control	13.9 $\pm$ 1.5	
	4	T2DM	15.1 $\pm$ 3.2	.032
		Control	18.3 $\pm$ 2.7	

Note: T2DM=Type 2 Diabetes Mellitus; VO_2=Oxygen Consumption

Table 13:

Means and Standard Deviations of Speed and Group on Absolute VO_2

	Speed (mph)	Group	Mean $\pm$ SD	p-value
Absolute VO_2 (L/min)	2	T2DM	0.84 $\pm$ 0.25	.350
		Control	0.71 $\pm$ 0.20	
	3	T2DM	1.17 $\pm$ 0.40	.345
		Control	0.99 $\pm$ 0.26	
	4	T2DM	1.46 $\pm$ 0.51	.533
		Control	1.30 $\pm$ 0.37	

Note: T2DM=Type 2 Diabetes Mellitus; VO_2=Oxygen Consumption

A significant difference was seen at 2 mph between individuals with type 2 diabetes and controls in Table 14. Individuals with type 2 diabetes had a higher MAP than the control group at each speed. There were no other significant values for MAP.

Table 14:

Means and Standard Deviations of Speed and Group on Mean Arterial Pressure

	Speed (mph)	Group	Mean ± SD	p-value
Mean Arterial Pressure (mmHg)	2	T2DM	93 ± 3	.007*
		Control	81 ± 7	
	3	T2DM	95 ± 4	.015
		Control	84 ± 8	
	4	T2DM	98 ± 5	.018
		Control	87 ± 9	

Note: *=Significant difference; T2DM=Type 2 Diabetes Mellitus

When ATM and LTM exercise were compared, heart rate was significantly different at 2 mph and 4 mph (see Table 15). Mean heart rate on LTM at 2 mph and 4 mph was higher than the mean heart rate on the ATM. *Figure 1* illustrates the mean heart rates at the varying speeds. The significant difference at 2 mph and 4 mph was also noted.

Table 15:

Means and Standard Deviations of Speed and Mode on Heart Rate

	Speed (mph)	Mode	Mean + SD	p-value
Heart Rate (bpm)	2	LTM	96 + 12	.001*
		ATM	87 + 10	
	3	LTM	107 + 14	.020
		ATM	102 + 10	
	4	LTM	133 + 17	.001*
		ATM	118 + 12	

Note: *=significant difference; LTM=Land treadmill; ATM=Aquatic treadmill

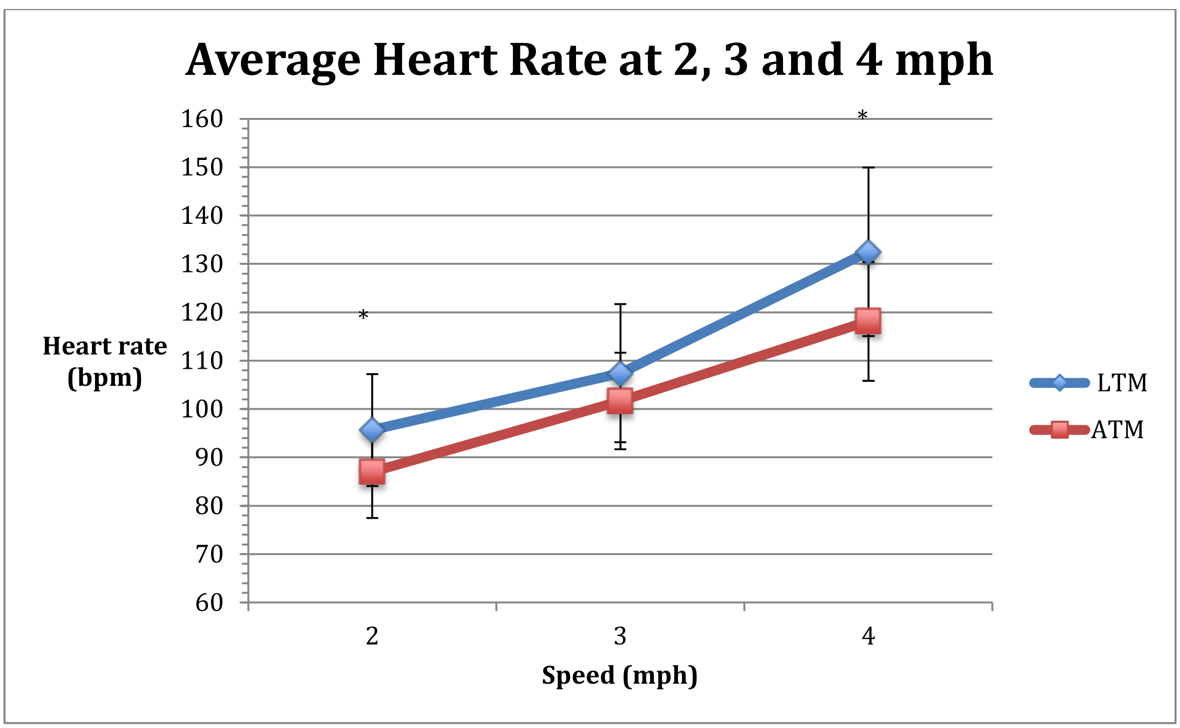

Figure 1: Average heart rate at 2, 3 and 4 mph

Note: *=significant difference between LTM and ATM at the same speeds

Similar speeds on the varying modes were compared in *Tables 16, 17* and *18.* The tables represent the values for relative VO_2, absolute VO_2, and MAP. No significant differences between the modes and similar speeds in the following tables were noted.

Table 16:

Means and Standard Deviations of Speed and Mode on Relative VO_2

	Speed (mph)	Mode	Mean $\pm$ SD	p-value
Relative VO_2 (ml/kg/min)	2	LTM	9.1 $\pm$ 0.7	.401
		ATM	9.8 $\pm$ 2.4	
	3	LTM	12.3 $\pm$ 1.1	.278
		ATM	13.8 $\pm$ 3.4	
	4	LTM	16.2 $\pm$ 2.7	.581
		ATM	17.2 $\pm$ 4.3	

Note: LTM=Land treadmill; ATM=Aquatic treadmill; VO_2=Oxygen Consumption

Table 17:

Means and Standard Deviations of Speed and Mode on Absolute VO_2

	Speed (mph)	Mode	Mean ± SD	p-value
Absolute VO_2 (L/min)	2	LTM	0.75 ± 0.21	.554
		ATM	0.80 ± 0.24	
	3	LTM	1.03 ± 0.30	.422
		ATM	1.13 ± 0.37	
	4	LTM	1.34 ± 0.37	.597
		ATM	1.42 ± 0.49	

Note: LTM=Land treadmill; ATM=Aquatic treadmill; VO_2=Oxygen Consumption

Table 18:

Means and Standard Deviations of Speed and Mode on Mean Arterial Pressure

	Speed (mph)	Mode	Mean ± SD	p-value
Mean Arterial Pressure (mmHg)	2	LTM	87 ± 7	.640
		ATM	87 ± 9	
	3	LTM	90 ± 8	.963
		ATM	90 ± 9	
	4	LTM	93 ± 9	.671
		ATM	92 ± 9	

Note: LTM=Land treadmill; ATM=Aquatic treadmill

There was a significant difference in all measures with an increase in speed on each mode of exercise. In *Figure 2,* heart rate for both individuals with type 2 diabetes and controls was significantly different at 2 and 4 mph between LTM and ATM. In *Figure 3,* there was a significant difference between the relative VO_2 of the two groups at 4 mph on LTM. Absolute VO_2 (*Figure 5*) notes no significant difference between group or mode. At 2 mph on the LTM, MAP was significantly different between individuals with type 2 diabetes and those without type 2 diabetes (*Figure 6*). Individuals with type 2 diabetes had a higher MAP at 2 mph those without type 2 diabetes.

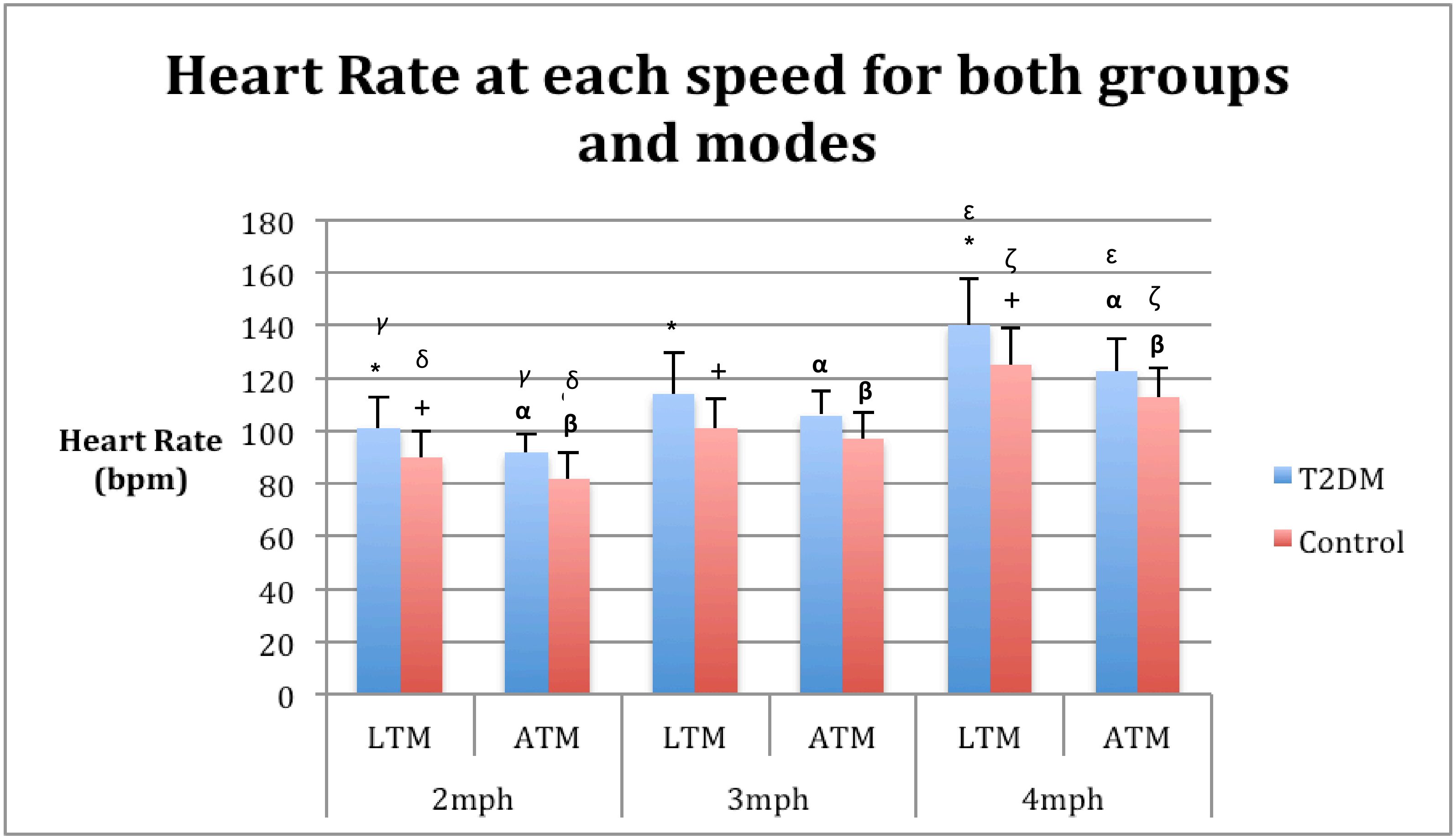

Figure 2: Means and standard deviations of treadmill, speed, and group for heart rate

Note: Means with same symbols are significantly different (p<.0125); T2DM=Individuals with type 2 diabetes

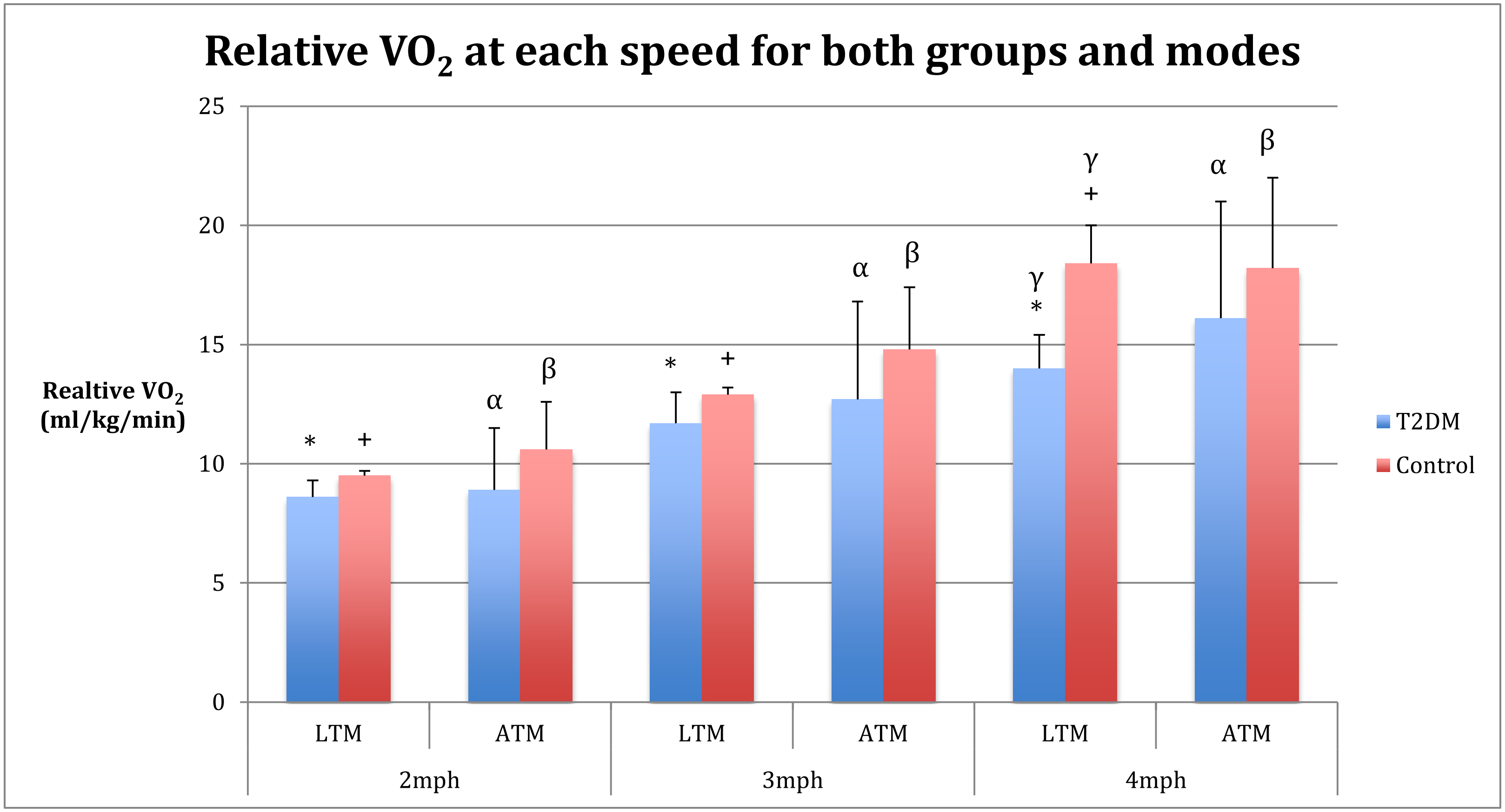

Figure 3: Means and standard deviation of treadmill, speed, and group for relative VO_2

Note: Means with same symbols are significantly different ($p<.0125$; VO_2=Oxygen consumption

T2DM=Individuals with type 2 diabetes

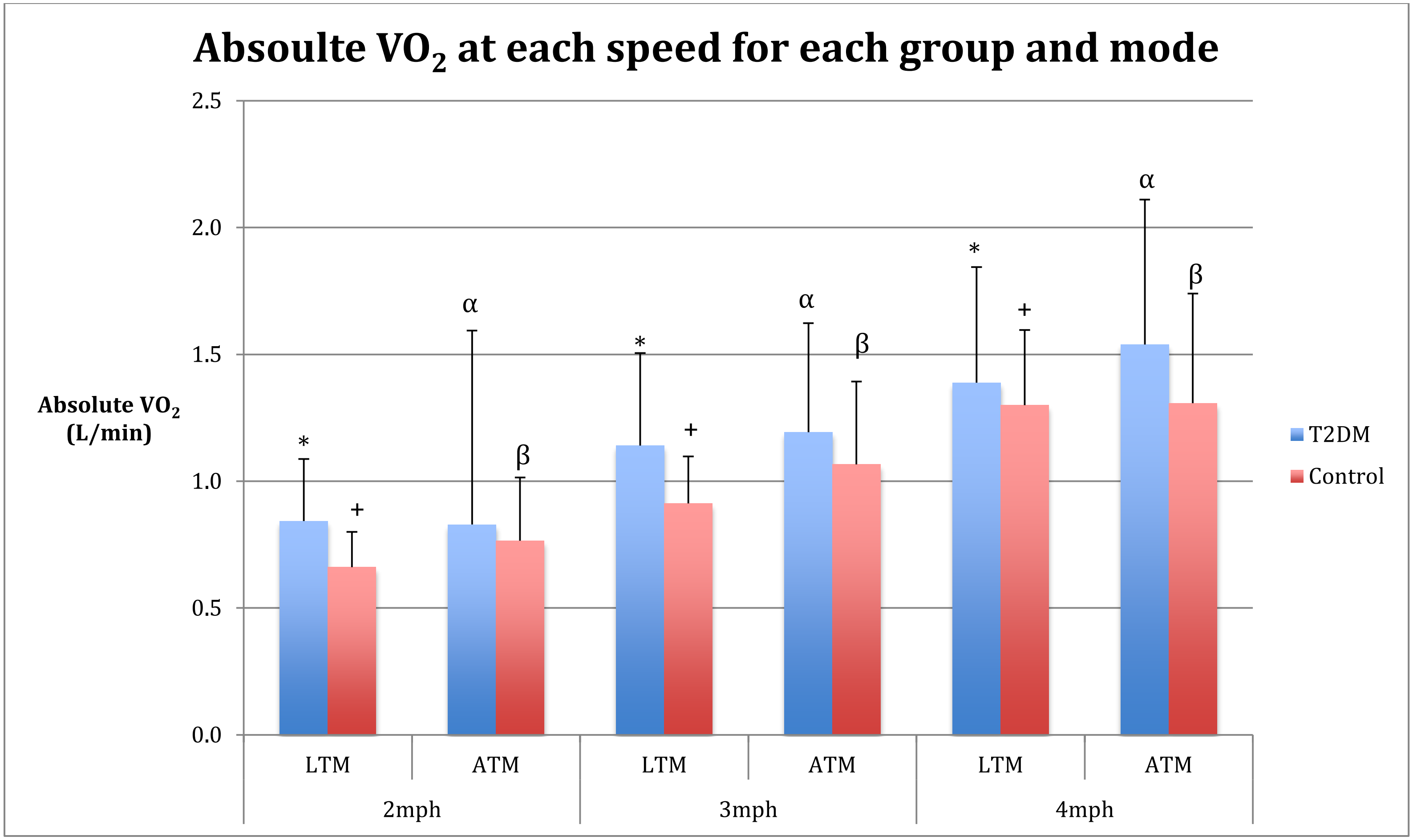

Figure 4: Means and standard deviations of treadmill, speed, and group for absolute VO_2

Note: Means with same symbols are significantly different ($p<.0125$); VO_2= Oxygen consumption; T2DM=Individuals with type 2 diabetes

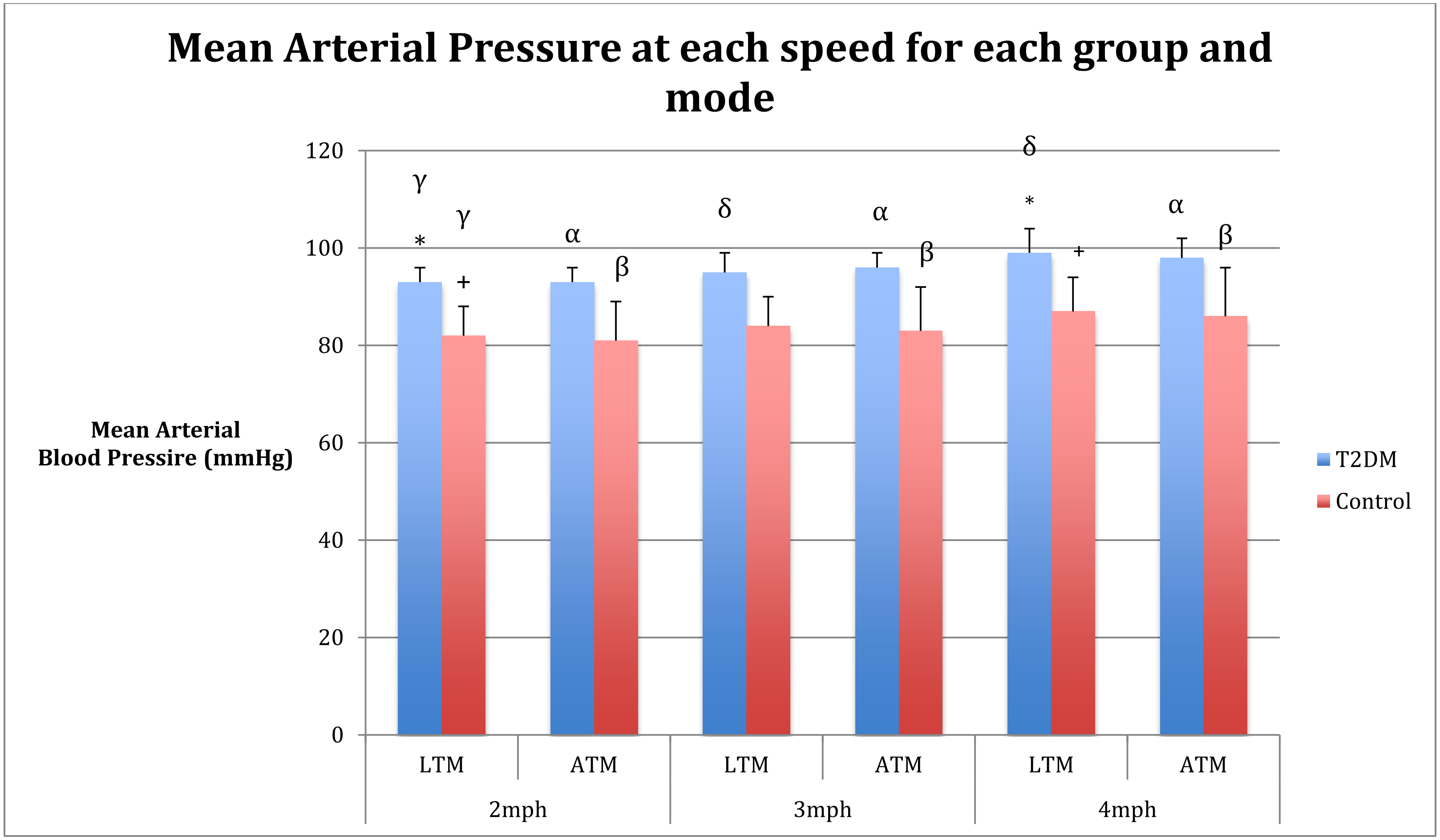

Figure 5: Means and standard deviation of treadmill, speed, and group for mean arterial pressure

Note: Means with same symbols are significantly different (p<.0125); T2DM=Individuals with type 2 diabetes

CHAPTER V

DISCUSSION

Analysis of Data

The purpose of this study was to compare the effect of ATM exercise and LTM exercise in individuals with type 2 diabetes. Results were compared to healthy individuals who were matched for age and gender. This is the first study in which common fitness parameters were measured and compared between those with type 2 diabetes and those without type 2 diabetes on an ATM and on an LTM at varying speeds.

When collapsed across mode and speed, there was a significant difference between groups only with respect to MAP (see table 7). Those with type 2 diabetes had a higher MAP compared to those who did not have type 2 diabetes. This rejects the first hypothesis, which stated that there would be no effect of group on heart rate, VO_2, or MAP. The difference in MAP may be attributed to some of the individuals with type 2 diabetes being treated pharmaceutically for hypertension. Type 2 diabetes affects metabolism of glucose rather than the transportation and use of oxygen. Therefore, heart rate and VO_2 may not be directly affected by type 2 diabetes. Healthy gender and age matched individuals may have similar heart rate and VO_2 values as the individuals with type 2 diabetes (Albright, 2009; Boden, 1994; Goodyear & Khan, 1998).

When collapsed across group and speed, there was a significant difference between modes of exercise only with respect to heart rate (see table 8). LTM exercise elicited a higher heart rate compared to ATM exercise. This rejects the second hypothesis, which stated that there would be no effect of mode on heart rate, VO_2, or MAP. The hydrostatic effect of water may increase venous return, thus increasing central venous pressure. Greater central venous pressure will increase end diastolic volume, thus increasing stroke volume, indicative of the Frank-Starling Law. An increase in stroke volume will increase cardiac output therefore decreasing the need for an increased heart rate to deliver oxygen to the body (Eldrich, 1987; Jasinskas, 2014). Hence heart rate during ATM exercise may not need to be as high as heart rate during LTM exercise to deliver oxygen to the working muscles. Lim and Rhi (2014) noted a similar significant difference in heart rate when comparing ATM exercise and LTM exercise. It is known that heart rate and VO_2 increase linearly with an increase in workload (ACSM, 2013). Although heart rate was found to be different between modes, a similar VO_2 was reported between ATM and LTM. This may be due to the increased ventilation during ATM exercise compared to LTM exercise. The water adds a resistance to the individual on the treadmill (Silvers et al., 2007). The combined effect of the resistance and aerobic exercise may increase ventilation during ATM exercise, leading to similar values for VO_2, during LTM and ATM exercise. Central venous pressure, systemic vascular resistance and cardiac output are all used in the calculation of MAP. The hydrostatic effect during ATM exercise should elicit an increase in central venous pressure and systemic vascular resistance. This would cause an increase in MAP during ATM exercise (Albright, 2009). The current study however recorded similar MAP values for both LTM and ATM. This may lead to the idea that peripheral resistance of the upper extremities decreased to negate the increased resistance of the lower extremities. Further investigation is needed to better understand this finding.

When collapsed across group and mode, there was a significant difference between speeds with respect to all variables (see table 9). There was a difference observed between 2 and 3 mph, 3 and 4 mph, and 2 and 4 mph for all variables. This rejects the third hypothesis, which stated that there would be no effect of speed on heart rate, VO_2, or MAP. This follows the idea that heart rate, VO_2, and SBP should increase with an increase in workload (ACSM, 2013).

When collapsed across speed, there was a significant difference between groups on the LTM with respect to relative VO_2 and MAP (see table 10). Those with type 2 diabetes had a lower relative VO_2, but a higher MAP, compared to those without type 2 diabetes. This rejects the fourth hypothesis, which stated that there would be no effect of the interaction of group and mode on heart rate, VO_2, or MAP. Relative VO_2 during LTM exercise may have been different because the two groups had varying training adaptations from previous exercise. With absolute VO_2 being similar between groups, this indicates that the individuals with type 2 diabetes had a higher body mass. Although not tested for significance, tables 5 and 6 display higher mean weight and percent body fat in individuals with type 2 diabetes compared to controls. The difference in MAP between groups during LTM exercise may be attributed to some of the individuals with type 2 diabetes being treated pharmaceutically for hypertension. The goal for medicinal treatment of hypertension in individuals with type 2 diabetes is 130/80 mmHg, which is higher than the normal healthy values of 120/80 mmHg (ACSM, 2013). This may be a contributing factor for a higher MAP in those with type 2 diabetes during LTM exercise. There were no differences between groups during ATM exercise. This may be due to the added effect of resistance during ATM exercise as well as the lower peak heart rate that was reached by all participants. Target HRR was reached during all LTM tests, however, 85% HRR was not met during ATM exercise before the protocol was complete. This may indicate that the LTM and ATM must be at varying speeds to elicit similar affects (Lim & Rhi, 2014).

When collapsed across mode, there was a significant difference between groups at 2 mph with respect to MAP (see tables 11 to 14). Those with type 2 diabetes had a higher MAP at 2 mph compared to the control group. This rejects the fifth hypothesis, which stated that there would be no effect of the interaction of group and speed on heart rate, VO_2, or MAP. As stated the differences in MAP may be attributed to the use of prescription medications for hypertension. This may have allowed for a higher resting blood pressure as well as a lower catecholamine effect during the increase in workload. Thus the blood pressure in the individuals with type 2 diabetes may not have increased as greatly with an increase in speed as it did in the healthy individuals making MAP at 3 and 4 mph similar. As stated previously, heart rate and VO_2 are not directly affected by type 2 diabetes. This may have allowed for similar responses at all speeds between groups.

When collapsed across group, there was a significant difference between modes at 2 and 4 mph with respect to heart rate (see tables 15 to 18). The heart rate during LTM exercise at both 2 and 4 mph was higher than during ATM exercise. This rejects the sixth hypothesis, which stated that there would be no effect of the interaction of mode and speed on heart rate, VO_2, or MAP. The difference in heart rate may be attributed to the effects of pressure exerted on the body by the water while performing ATM exercise. There is a similarity at 3 mph in terms of heart rate. This may be due to a slight nonlinear decrease in heart rate at 3 mph during LTM as this is a typical walking pace for most individuals (ACSM, 2013). The similar effect seen in VO_2 may be due to the previously mentioned increase in ventilation during ATM exercise compared to LTM exercise. Additionally, the similarities of MAP between speed and mode may be explained with the previously mentioned idea on total peripheral resistance.

The seventh hypothesis was also rejected see figures 2 to 5), which states that there would be no effect of the interaction of group, mode and speed on heart rate, VO_2, or MAP. In those with type 2 diabetes, heart rate was different between ATM and LTM exercise at 2 and 4 mph. Additionally, heart rate was different between all speeds on both ATM and LTM for both groups. Heart rate, in healthy individuals void of sudden onset of cardiac dysrhythmias, is expected to increase with an increase in workload (ACSM, 2013; Albright, 2009). As noted in chapter one, the hydrostatic effect of water increases with an increase in vertical depth (Eldrich, 1987; Jasinskas, 2014). This pressure may alter how blood is distributed throughout the body, thus altering heart rate. In a study published in 2014, Conners et al. used the ATM as a training mode for individuals with type 2 diabetes. The individuals completed three ATM sessions with the water height at the xiphoid process for eight weeks. Conners et al. noted a significant decrease in resting heart rate. Pre-training resting heart rate was approximately 83 bpm, while post training resting heart rate was approximately 75 bpm. Both the current thesis and the investigation by Conners et al. show a significant effect of ATM exercise on heart rate.

Relative VO_2 was different at 4 mph during LTM exercise between individuals with type 2 diabetes and the control group. In those with type 2 diabetes, relative VO_2 was also different between all speeds on both LTM and ATM. Similar results were observed in those without type 2 diabetes. Relative VO_2 is expected to increase with an increase in workload (ACSM, 2013; Albright, 2009). The difference at 4 mph between groups may be due to previous training difference between the two groups.

In regards to absolute VO_2 there were no differences between groups or modes. All speeds during LTM and ATM exercise were different for individuals with type 2 diabetes. Similar results were observed in those void of type 2 diabetes. Absolute VO_2 is expected to increase with an increase in workload. Although there were differences in relative VO_2, absolute VO_2 does not take into account the participants body weight. Two individuals with different body weights may take in the same amount of air; however, a better-trained individual should be able to utilize oxygen more effectively.

At 2 mph on the LTM, MAP was different between individuals with type 2 diabetes and the control group. However, MAP was not different at all speeds on LTM. LTM was different between 2 and 4 mph for both groups. For individuals with type 2 diabetes MAP was different between 3 and 4 mph. For ATM, all speeds were significant for all groups. Some individuals with type 2 diabetes were on medication for hypertension. This may have altered the effect of exercise on MAP.

Limitations

Potential errors may have occurred in collection of blood pressure. Inaccurate readings are possible due to malfunction or misuse of equipment. Over-compression or under-inflating the cuff could lead to a possible misreading.

Additionally, because the cuff was used above water, some water getting in the bulb or cuff may have hindered proper reading. The investigator listening for Korotkoff sounds may have misheard the steps of the participant or other noises, such as the treadmill or various background noises, as Korotoff sounds.

The masks used to analyze the respiratory gases of each participant were fitted to individual faces, so there is a possibility that an improper fitting of the masks occurred. Specifically, there may have been areas of the mask that let too much air escape without being channeled to the respiratory gas analyzer. Participants also may have increased their ventilation by talking during the study. All participants were asked to talk minimally; however, they were instructed to talk if they needed to notify the investigators regarding how they were feeling or to request to stop the exercise.

Heart rate was obtained by using a heart rate monitor. Malfunction of equipment could have led to possible misreading of heart rate. Two polar watches were used to aid in negating the batteries of one watch stopping.

A limitation for this study includes water depth. Water depth could only be controlled by height of the participant as the ATM was in a large pool rather than a therapeutic pool. The height of the participant was recorded in aims to maintain the water height at the desired level. However, some participants sank below the desired level while striding on the treadmill. Although all water was maintained below chest line, it occasionally rose above the xiphoid process during strides.

Another limitation of the protocol was the lack of an acclimation session. The protocols were completed twice and averaged in aims to avoid values due to inexperience. Both protocols however were completed on the same day. Allowing for an acclimation session may have reduced any anticipation, anxiety, or fear regarding the exercise.

Additionally, the two bouts of exercise for one mode were completed after a 15-minute rest period. Some participants were untrained so recovery was not as rapid. Allowing a longer rest period may have enabled all participants to fully recover.

Finally, participants are a limitation. There were only 10 participants used and only two were males. The small amount of males did not allow for comparison across sex. A larger group of participants may allow for more significant findings.

Future Work

The study consisted of 10 participants. A similar study with more participants may aid in decreasing limitations. Additionally, increasing the number of males may decrease limitations. Aside from numbers, participants with varying health conditions other than type 2 diabetes may be used to investigate effect of ATM exercise compared to LTM exercise.

The protocol may also be changed in a future study. Allowing for an acclimation session and/or a longer rest period between the two exercise sessions may be added. The protocol may also implement 3-minute stages rather than 5-minute stages with an ending heart rate lower than 85% of HRR.

Use of water resistant equipment may also be used in future work. Water resistance automated blood pressure cuffs and gas analysis systems may aid in minimizing errors in collection. This equipment was not available for this study.

Finally, future studies may include an analysis between ATM exercise in large pools and ATM exercise in a therapeutic pool where water depth may be changed and monitored due to height. A comparison of the therapeutic pool ATM exercise and LTM exercise could also be further investigated. Maintaining water height relative to all individuals on the ATM may elicit significant findings.

Conclusion

ATM exercise has been investigated in many previous studies in aims to better understand its effect on the body (Becker, 1994; Chewning, 2011; Choukroun, 2011; Church et al., 2010; Conners, 2014; Kays & Varene, 2011; Edich, 1987; Fujshima & Shimizu, 2003; Gleim & Nicholas, 1989; Green et al., 2009; Jasinskas, 2014; Johnson, 1994; Kamiko, 2011; Lim & Rhi, 2014; Migita et al., 1996; Saunders & Kennedy, 1998; Shono et al, 2001; Silvers, Rutledge and Dolny, 2007). ATM exercise has been investigated as a therapeutic tool (Becker, 1994; Jasinskas, 2014; Johnson, 1994; Shono et al, 2001), and as a mode of exercise (Church et al., 2010; Conners, 2014; Green et al., 2009; Kamiko, 2011; Lim & Rhi, 2014; Migita et al., 1996; Silvers, Rutledge and Dolny, 2007).

Overall, this experiment produced significantly different values for heart rate on ATM and LTM with ATM being lower. Oxygen consumption was not found to be significantly different between modes, although relative VO_2 was different between groups. Finally, MAP was found to be significantly different between speeds, groups and modes. This provides evidence that ATM exercise may elicit varying effects when compared to LTM exercise in individuals with type 2 diabetes.

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APPENDIX A

Skinfold Sites Taken from ACSM 9th ed.

Abdominal – Vertical fold; 2 cm to the right of the umbilicus

Triceps – Vertical fold; on the posterior midline of the upper arm, halfway between the acromion and olecranon processes, with the arm held freely to the side of the body

Biceps – Vertical fold; on the anterior aspect of the arm over the belly of the biceps muscle, 1 cm above the level used to mark the tricep site

Chest/Pectoral - Diagonal fold; one half the distance between the anterior axillary line and the nipple (men), or one third of the distance between the anterior axillary line and the nipple (women)

Medial calf – Vertical fold; at the maximum circumference of the calf on the midline of its medial border

Midaxillary – Vertical fold; on the midaxillary line at the level of the xiphoid process of the sternum (An alternate method is horizontal fold taken at the level of the xiphoid/ sternal border in the midaxillary line.)

Subscapular – Diagonal fold; (at a 45 – degree angle); 1 to 2 cm below the inferior angle of the scapula

Suprailiac - Diagonal fold; in line with the natural angle of the iliac crest taken in the anterior axillary line immediately superior to the iliac crest

Thigh- Vertical fold; on the anterior midline of the thigh, midway between the proximal border of the patella and the inguinal crease (hip) (ASCM, 2013).

APPENDIX B

Raw Data

Table 1:

Descriptive Data for Participants

Participants	Sex	Age (yrs)	Height (cm)	Weight (kg)	Body Fat (%)
1	F	45	165	117	32.7
2	F	54	169	112	33.6
3	F	58	172	69	28.2
4	F	54	163	72	32.7
5	M	45	182	111	30.6
6	F	46	167	59	18.7
7	F	55	172	73	29.9
8	F	59	170	68	28.3
9	F	51	163	61	29.0
10	M	46	179	96	28.5

Table 2:

Raw Data for Participant 1

	Mode	Speed (mph)	HR (bpm)	SBP (mmHg)	DBP (mmHg)	MAP (mmHg)	VO_2 (L/min)	VO_2 (ml/kg/min)
1	LTM	2	106	122	82	95	0.96	8.2
		3	120	123	82	96	1.26	11.0
		4	160	137	85	102	1.76	15.1
	ATM	2	96	112	80	91	1.02	8.7
		3	106	118	82	94	1.43	12.2
		4	129	123	82	96	1.99	17.0

Table 3:

Raw Data for Participant 2

	Mode	Speed (mph)	HR (bpm)	SBP (mmHg)	DBP (mmHg)	MAP (mmHg)	VO_2 (L/min)	VO_2 (ml/kg/min)
2	LTM	2	109	123	79	94	1.04	9.3
		3	128	134	80	98	1.55	13.8
		4	152	142	82	102	1.73	15.5
	ATM	2	90	120	78	92	0.54	4.8
		3	111	126	80	95	0.75	6.7
		4	127	130	80	97	1.05	9.4

Table 4:

Raw Data for Participant 3

	Mode	Speed (mph)	HR (bpm)	SBP (mmHg)	DBP (mmHg)	MAP (mmHg)	VO_2 (L/min)	VO_2 (ml/kg/min)
3	LTM	2	111	122	72	89	0.54	7.8
		3	125	123	72	89	0.72	10.4
		4	144	128	72	91	0.92	13.3
	ATM	2	100	116	78	91	0.62	8.9
		3	114	125	78	94	0.79	11.5
		4	132	126	78	94	0.91	13.1

Table 5:

Raw Data for Participant 4

	Mode	Speed (mph)	HR (bpm)	SBP (mmHg)	DBP (mmHg)	MAP (mmHg)	VO_2 (L/min)	VO_2 (ml/kg/min)
4	LTM	2	82	113	78	90	0.62	8.6
		3	90	123	78	93	0.80	11.0
		4	114	137	78	98	0.86	12.0
	ATM	2	80	121	77	92	0.82	11.3
		3	91	131	77	95	1.23	17.1
		4	102	139	78	98	1.54	21.3

Table 6:

Raw Data for Participant 5

	Mode	Speed (mph)	HR (bpm)	SBP (mmHg)	DBP (mmHg)	MAP (mmHg)	VO_2 (L/min)	VO_2 (ml/kg/min)
5	LTM	2	99	126	82	97	1.06	9.3
		3	108	131	82	98	1.38	12.2
		4	130	146	82	103	1.67	14.4
	ATM	2	94	132	82	99	1.15	10.8
		3	108	141	82	102	1.76	15.8
		4	127	148	82	104	2.22	19.8

Table 7:

Raw Data for Participant 6

	Mode	Speed (mph)	HR (bpm)	SBP (mmHg)	DBP (mmHg)	MAP (mmHg)	VO_2 (L/min)	VO_2 (ml/kg/min)
6	LTM	2	86	100	58	72	0.51	9.4
		3	94	101	58	72	0.72	13.3
		4	116	106	58	74	1.04	18.4
	ATM	2	80	99	58	72	0.75	12.6
		3	94	103	59	74	1.03	17.4
		4	104	111	61	78	1.22	20.6

Table 8:

Raw Data for Participant 7

	Mode	Speed (mph)	HR (bpm)	SBP (mmHg)	DBP (mmHg)	MAP (mmHg)	VO_2 (L/min)	VO_2 (ml/kg/min)
7	LTM	2	93	115	68	84	0.70	9.6
		3	106	122	69	87	0.93	12.7
		4	133	127	69	88	1.53	20.9
	ATM	2	84	106	68	81	0.61	8.3
		3	103	112	69	83	0.86	11.8
		4	120	116	69	85	0.98	13.4

Table 9:

Raw Data for Participant 8

	Mode	Speed (mph)	HR (bpm)	SBP (mmHg)	DBP (mmHg)	MAP (mmHg)	VO_2 (L/min)	VO_2 (ml/kg/min)
8	LTM	2	81	111	68	82	0.63	9.8
		3	89	117	68	84	0.91	12.8
		4	109	124	70	88	1.13	16.6
	ATM	2	75	122	76	91	0.60	8.6
		3	86	128	76	93	0.85	12.3
		4	101	135	77	96	1.02	14.8

Table 10:

Raw Data for Participant 9

	Mode	Speed (mph)	HR (bpm)	SBP (mmHg)	DBP (mmHg)	MAP (mmHg)	VO_2 (L/min)	VO_2 (ml/kg/min)
9	LTM	2	106	110	70	83	0.59	9.7
		3	116	118	70	86	0.81	13.2
		4	146	127	70	89	1.11	18.2
	ATM	2	98	105	62	76	0.68	11.1
		3	112	114	62	79	0.96	15.7
		4	129	122	62	82	1.27	20.7

Table 11:

Raw Data for Participant 10

	Mode	Speed (mph)	HR (bpm)	SBP (mmHg)	DBP (mmHg)	MAP (mmHg)	VO_2 (L/min)	VO_2 (ml/kg/min)
10	LTM	2	87	115	72	86	0.88	9.1
		3	101	128	72	91	1.21	12.6
		4	123	136	72	93	1.70	17.8
	ATM	2	75	124	78	93	1.20	12.5
		3	93	131	81	98	1.64	17.1
		4	113	140	85	103	2.05	21.4

APPENDIX C

Approval from Institutional Review Board

Institutional Review Board
Office of Research and Sponsored Programs
P.O. Box 425619, Denton, TX 76204-5619
940-898-3378
email: IRB@twu.edu
http://www.twu.edu/irb.html

DATE: February 16, 2015

TO: Dr. Brandon Rhett Rigby
Kinesiology

FROM: Institutional Review Board - Denton

Re: Approval for Cardiorespiratory Responses During Exercise on an Underwater Treadmill and Overground Treadmill in Adults with Type 2 Diabetes (Protocol #: 18024)

The above referenced study has been reviewed and approved at a fully convened meeting of the Denton Institutional Review Board (IRB) on 1/16/2015. This approval is valid for one year and expires on 1/16/2016. The IRB will send an email notification 45 days prior to the expiration date with instructions to extend or close the study. It is your responsibility to request an extension for the study if it is not yet complete, to close the protocol file when the study is complete, and to make certain that the study is not conducted beyond the expiration date.

If applicable, agency approval letters must be submitted to the IRB upon receipt prior to any data collection at that agency. A copy of the approved consent form with the IRB approval stamp is enclosed. Please use the consent form with the most recent approval date stamp when obtaining consent from your participants. A copy of the signed consent forms must be submitted with the request to close the study file at the completion of the study.

Any modifications to this study must be submitted for review to the IRB using the Modification Request Form. Additionally, the IRB must be notified immediately of any adverse events or unanticipated problems. All forms are located on the IRB website. If you have any questions, please contact the TWU IRB.

cc. Dr. Charlotte (Barney) Sanborn, Kinesiology

APPENDIX D

Informed Consent

Exercise Physiology Laboratory
304 Administration Dr.
Denton, TX 76204-5647

TWU
TEXAS WOMAN'S UNIVERSITY
DENTON DALLAS HOUSTON

Office: 940-898-2473
Fax: 940-898-2581
brigby@twu.edu

TEXAS WOMAN'S UNIVERSITY
CONSENT TO PARTICIPATE IN RESEARCH
for a Research Study entitled

"CARDIORESPIRATORY RESPONSES DURING EXERCISE ON AN UNDERWATER TREADMILL AND OVERGROUND TREADMILL IN ADULTS WITH TYPE 2 DIABETES"

PURPOSE

Underwater treadmill exercise combines aerobic and resistance training components. In type 2 diabetics, aerobic exercise has numerous health benefits, including reducing body fat percentage and improving how the body reacts to the effects of insulin. Similarly, weight-lifting can also enhance how the body reacts to the effects of insulin and can increase muscle mass, thereby enabling activities of daily living (ADLs) to be performed with greater ease. Little is known regarding the acute cardiorespiratory responses to underwater treadmill exercise compared to responses observed to overground treadmill exercise in type 2 diabetics. **The purpose of this study is to characterize cardiorespiratory responses during an acute bout of exercise on an underwater treadmill and on an overground treadmill in adults with type 2 diabetes, and compare the results to a group of adults without type 2 diabetes.**

PARTICIPANT REQUIREMENTS and PRELIMINARY SCREENING Participant Criteria

Up to 20 adults will be recruited for this study, without regard to fitness level. Ten adults will be diagnosed with type 2 diabetes and 10 adults will be without diabetes. Both groups will be between 40 and 80 years of age. Enrollment is open to men and women of all ethnicities.

In order to be eligible to participate, you must have the following characteristics:

1. be at least 5 feet, 7 inches in height;
2. have the ability to follow verbal directions;
3. are without orthopedic problems that could be exacerbated by exercise;
4. are without a diagnosed congenital heart condition or known cardiovascular condition that would preclude you from exercise;
5. are free from surgical procedures performed within the past 6 months;
6. be comfortable in an aquatic environment

 Initials ______

If you are currently taking medication and/or are participating in other modes of therapy, we request that you do not alter the schedules of your medication or therapy throughout the duration of the study.

EXPERIMENTAL METHODS and APPROACH

The preliminary visit and testing session will take place in Pioneer Hall, in the swimming pool and in the Exercise Physiology Laboratory, Texas Woman's University, Denton, TX. Please do not hesitate to ask questions at any point during the study.

Preliminary Visit

An initial familiarization session will occur at TWU for both groups. At this time, you will be screened, familiarized with the study protocol and given the informed consent form to allow for participation in the study. At this time, you will be notified of the order of the testing sessions (i.e., underwater treadmill session first or overground treadmill session first).

Testing Sessions

All experimental data will be collected over two randomized sessions, which will take place 4-7 days apart. The sessions will be scheduled via email at a time that is convenient to you. Photos and/or video may be recorded during the testing sessions with your permission. This media will only be used for educational purposes. Prior to the testing sessions, all experimental procedures will be reviewed with you, and you will be asked to provide verbal consent.

Your height and weight will be measured first. Weight will be assessed using a digital scale and height will be assessed using measuring tape. You will then be fitted with a heart rate monitor chest strap. The respiratory gas analysis equipment will then be fitted on you, including the facemask. A five-minute rest period will then begin. During this time, resting heart rate, blood pressure, and respiratory gases will be measured in a seated position. Resting heart rate will be measured using the chest strap and a wireless monitor. Resting blood pressure will be measured manually using an aneroid sphygmomanometer and stethoscope.

Underwater Treadmill Session

Before entering the swimming pool, you will be expected to be in proper swimming attire (i.e., no street clothes, no natural fibers, shoes). With the heart rate monitor and gas analyzer still attached, you will be asked to step into the swimming pool in the shallow end and step onto the treadmill. The height of the water should be no higher than halfway between the naval and nipple line. Heart rate, blood pressure and respiratory gasses during exercise will be measured in the same manner as at rest. You will straddle the treadmill with both legs while the investigator turns on the treadmill. To warm-up, you will walk at 2.0 mph at 0% grade for 5 min. The treadmill will then increase in 1.0 mph increments at 0% grade until 5.0 mph is reached, with each stage lasting 3-5 min or until a steady state is reached. The test will end once you reach a 3-5 min duration at 5.0 mph on the treadmill or you reach 85% of your heart rate reserve, whichever comes first. Blood pressure will be measured once you reach the steady state. Once the protocol has been completed, a cool-down period will begin, with the speed of the treadmill decreasing by 1.0 mph every minute until it reaches 0 mph. You will then be asked to step off of the treadmill, take off the facemask, climb out of the pool, and sit quietly for approximately 15 minutes. During this time, you will be covered with dry towels and fitted with a new mask. You will then be asked to repeat the underwater treadmill protocol, starting with the warm-up stage.

Overground Treadmill Session

The overground treadmill session will be conducted in the same manner as the underwater treadmill session, with the exception that the treadmill in this session will be on dry land and all data collection will take place in the Exercise Physiology Laboratory in Pioneer Hall.

In order for you to complete all requirements of this study, the total time commitment

is: For both groups:	**preliminary visit:**	**0.5 hour**
	underwater treadmill session:	**1.5 hours**
	overground treadmill session:	**1.0 hour**
	TOTAL TIME COMMITMENT:	**3.0 hours**

Participant Benefits

For your participation, you will receive:

1. your individual results from the testing.

2. a written summary of the findings upon completion of the study.

Potential Risks and Protection of Participants

RISK	STEPS TO MINIMIZE RISK
Injury sustained while exercising on the treadmills	The primary risk of walking/jogging on the treadmill is falling off of the treadmill. Proper supervision will be undertaken to ensure the participant does not fall off, both in the water and overground. For both methods, one person will be standing on each side of the treadmill and another person will be standing behind the treadmill. Also, handrails are present on each side of the treadmill and the participant will be asked to grip the handrails if he/she begins to lose their balance.
RISK	STEPS TO MINIMIZE RISK
Sudden cardiac death	According to the American College of Sports Medicine, there is little risk during submaximal exercise. However, risks include a sudden cardiac event or even death. All investigators are CPR/AED certified. All of the physiologic risks inherent with exercise testing will be minimized through preliminary screening, adherence to

	published by the American College of Sports Medicine, and personal monitoring of each test by trained personnel. Individuals with congenital heart disease or known cardiovascular disease will be excluded.
RISK	STEPS TO MINIMIZE RISK
Pulls/strains of ligaments, tendons, and/or muscles	According to the American College of Sports Medicine, there is little risk during submaximal exercise. However, risks include injury to muscles or joints. All of the physiologic risks inherent with exercise testing will be minimized through preliminary screening, adherence to standards of practice for exercise testing that are published by the American College of Sports Medicine, and personal monitoring of each test by trained personnel.
RISK	STEPS TO MINIMIZE RISK
Illness due to hot/cold environments	There is little risk with exercising in the pool at Pioneer Hall, as the water temperature is kept in a strict temperature range. Ambient temperature in the laboratory where the overground treadmill testing will take place is also kept in a narrow temperature range. These temperatures are monitored by the facilities manager in Pioneer Hall, Beth Palmer. If the temperature in the pool or the laboratory is not conducive to testing, the test will be suspended until the situation is rectified.
RISK	STEPS TO MINIMIZE RISK
The risks associated with fatigue	While exercising on the treadmills, the testing sessions will be terminated before the participant reaches a high or vigorous intensity (i.e., 85% of their heart rate reserve). Adequate time will be given to the participant between trials (15 min) and between testing sessions (4-7 days). More time between trials will be granted to the participant if needed.
RISK	STEPS TO MINIMIZE RISK
Loss of confidentiality	It is possible that there might be a loss of participant confidentiality with data stored offline. To minimize this risk, all data forms collected will be coded using alphanumeric IDs. A single identification form linking names with their respective IDs will be kept in a separate folder from the other data. Persons not associated with the study will have no access to the folders. Data collection sheets will be locked in a file cabinet in Pioneer Hall 123B. There is also a potential risk of loss of confidentiality in all email, downloading, and internet transactions.
RISK	STEPS TO MINIMIZE RISK
Loss of anonymity	It is possible that multiple participants may be

	such that the participant is exposed to the general public; because of this, participants will be informed (before the study begins) that the loss of anonymity may be present. The participant has the ability to request a separate time to complete the pool assessment; however, anonymity cannot be protected even when the pool is closed due to evening classes in Pioneer Hall and the glass windows that allow for the public to view the pool. The participant may withdraw from the study at any time without penalty.
RISK	STEPS TO MINIMIZE RISK
Embarrassment	Words of encouragement and motivational language will be spoken by the investigators in the event the participant is embarrassed due to his/her performance during the testing sessions. In the event that one might get embarrassed based on his/her appearance in an aquatic setting, the investigators will remind the participant that participation is voluntary and the participants may withdraw from the study at any time. Every attempt will be made to have Ms. Foreman be the lead investigator for the sessions involving female participants and to have Dr. Rigby be the lead investigator for sessions involving male participants
RISK	STEPS TO MINIMIZE RISK
Emotional discomfort	Participation is voluntary and the participants may withdraw from the study at any time. Every attempt will be made to have Ms. Foreman be the lead investigator for the sessions involving female participants and to have Dr. Rigby be the lead investigator for sessions involving male participants.
RISK	STEPS TO MINIMIZE RISK
Coercion	Services provided to the participants will not be affected by participation/non-participation in the study. Participation is voluntary and the participants may withdraw from the study at any time.

At the beginning of each session, all of the procedures will be briefly reviewed with you. We will obtain your verbal consent to participate in the day's procedures.

The researchers will try to prevent any problem that could happen because of this research. You should let the researchers know at once if there is a problem and they will help you. However, TWU does not provide medical services or financial assistance for injuries that might happen because you are taking part in this research.

YOUR RIGHTS TO PRIVACY

Confidentiality will be protected to the extent that is allowed by law. All individual information obtained in this study will remain confidential and your right to privacy will be maintained. Data collected will be used for research purposes only and will be limited to access by the investigators of this study. Only data reported as group means or responses will be presented in scientific meetings and published in scientific journals.

QUESTIONS ABOUT THIS RESEARCH

As investigators, it is our obligation to explain all of the procedures to you. We want to make sure that you understand what is required of you and what you can expect from us in order to complete this research project. Please do not hesitate to inquire about the research, your rights and responsibilities as the participant, or our roles as the investigators now or at any time throughout the study.

YOUR CONSENT TO PARTICIPATE

Participation in this research is entirely voluntary. Your decision whether or not to participate will not jeopardize your future relations with Texas Woman's University and the Department of Kinesiology. You may withdraw your consent and discontinue participation at any time and for any reason without prejudice. Discontinuing your participation will involve no penalty of any kind.

Failure to comply with all of the procedures and to follow the instructions necessary for reliable and valid scientific measurements may result in termination of your participation in this study without your consent. You may be asked to withdraw if you fail to comply with all of the requirements for participation listed above. If you are withdrawn from participation by one of the investigators, our decision will not jeopardize your future relations with Texas Woman's University and the Department of Kinesiology.

CONTACT INFORMATION

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YOU WILL BE GIVEN A COPY OF THIS SIGNED AND DATED CONSENT FORM TO KEEP. IF YOU HAVE ANY QUESTIONS ABOUT THE RESEARCH STUDY YOU SHOULD ASK THE RESEARCHERS. IF YOU HAVE ANY QUESTIONS ABOUT YOUR RIGHTS AS A PARTICIPANT IN THIS RESEARCH OR THE WAY THIS STUDY HAS BEEN CONDUCTED, YOU MAY CONTACT THE TEXAS WOMAN'S UNVERSITY OFFICE OF RESEARCH AND SPONSORED PROGRAMS AT 940-898-3378 OR VIA EMAIL AT IRB@twu.edu

Participant's Signature	Date	Investigator Obtaining Consent	Date
Printed Name		Printed Name	