

THE RELATIONSHIP BETWEEN PHYSICAL ACTIVITY  
AND BODY COMPOSITION IN INDIVIDUALS  
WITH TYPE-1 DIABETES

by

Jennifer Naus

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Project Approved:

Supervising Professor: Phil Esposito Ph.D.

Department of Kinesiology

Meena Shah, Ph.D.

Department of Kinesiology

Gina Hill, Ph.D., RD, LD

Department of Nutritional Sciences

## ABSTRACT

Physical activity has been considered important for the management of diabetes, along with diet and medication. There has been lots of research examining the importance of physical activity for controlling type-2 diabetes, but research looking at physical activity as a way to help control type-1 diabetes along with insulin is limited. The purpose of this study is to determine the relationship between physical activity and body composition in individuals with type-1 diabetes. This study consisted of 10 young adults aged 16 to 22. There were five males and five females. Subjects were recruited by word of mouth and from a summer camp for individuals with diabetes. All participants were measured for height, weight, waist circumference, hip circumference, percent body fat, calculated BMI, and hip-to-waist ratio. Percent fat and BMI were calculated using the DEXA, the gold standard for body composition. Physical activity was measured using accelerometry. Physical activity was then calculated to time spent in light and moderate-to-vigorous physical activity. The results showed an association between lower amounts of physical activity and increased body mass index, percent fat, waist circumference, and waist to hip ratio for males. There was a statistical significance for the correlation between lower physical activity and increased physical activity for males. An association between lower physical activity and higher body mass index and higher percent fat. The hypothesis was supported for males, but the relationship between physical activity and body composition needs to be explored further for both males and females with type-1 diabetes.

TABLE OF CONTENTS

INTRODUCTION .....	1
REVIEW OF LITERATURE .....	1
METHOD .....	6
Participants.....	6
Apparatus .....	6
Procedure .....	7
Design and Analysis .....	10
RESULTS .....	11
DISCUSSION .....	15
REFERENCES .....	18

## INTRODUCTION

Diabetes Mellitus is a chronic disease that results in increased glucose or blood sugar levels (Torpy, 2009). There are two types of diabetes. Type-2 diabetes or insulin resistant diabetes occurs when the body produces insulin but is unable to process glucose efficiently (Torpy, 2009). Type-1 diabetes also referred to as juvenile diabetes is often diagnosed during childhood or adolescence and accounts for approximately 5-10% of diabetes cases in the United States (Weltman, Saliba, Barrett, & Weltman, 2009). In fact, it is one of the most common chronic childhood diseases, but it can be diagnosed at any age (Atkinson, Eisenbarth, & Michels, 2013). As of 2012, 9.3% of the United States population or 29.1 million Americans had diabetes (CDC, 2014). Of those 29.1 million Americans, 21 million were actually diagnosed while 8.1 million remained undiagnosed (American Diabetes Association, 2014). In Texas alone, 1.8 million adults aged 18 years of age and up have been diagnosed with diabetes (Texas Behavioral Risk Factor Surveillance System, 2010).

## REVIEW OF LITERATURE

There are two forms of type-1 diabetes, which include the following: type- 1A and type- 1B. Type- 1A occurs as a result of an immune mediated attack on  $\beta$  cells. In contrast, type- 1B has an unknown cause and occurs less often compared to type- 1A (Daneman, 2006). Pancreatic  $\beta$ -cells are responsible for producing insulin, and insulin helps process glucose and lower the amount of glucose in the blood. Because pancreatic  $\beta$ -cells are destroyed in type-1 diabetes there is no insulin to control blood glucose, and the result is hyperglycemia (Brazeau, Leroux, Mircescu, & Rabasa-Lhoret, 2012). Individuals with type-1 diabetes can also develop severe metabolic decompensation with

ketoacidosis or moderate, fasting hyperglycemia that can quickly transform to severe hyperglycemia or ketoacidosis (Weltman et al., 2009). As a result of the destruction of  $\beta$ -cells, the body becomes insulin dependent. Therefore, individuals with type-1 diabetes require either insulin injections or insulin pumps in order to manage the disease and prevent exacerbation of various complications (Daneman, 2006). According to Torpy, complications may include “heart disease, poor circulation, blindness, kidney failure, poor healing, stroke, and other neurological disease” (2009, p. 301).

In order to prevent further complications from diabetes and manage the disease, there are several clinical interventions. These interventions include medical therapy, nutritional therapy, diabetes self-management education, psychosocial assessment and care, hypoglycemia awareness management, immunizations, and exercise (Weltman et al., 2009). Exercise is important and essential to health in terms of quality of life and well-being. In order to reach optimal health individuals should participate in exercise programs that aim to improve cardiorespiratory fitness, body composition, and muscular fitness (Weltman et al., 2009). Therefore, it is important that diabetics make exercise a part of their life because it can reduce the risk of complications as well as mortality (Weltman et al., 2009). According to Weltman et al., the exercise programs should include “exercise duration, intensity, frequency, mode, rate of progression, and specificity” as recommended by the American College of Sports Medicine (2009, p. 436). The recommended amount of physical activity for adults is at least 150 minutes of moderate intensity exercise a week (ACSM, 2015). It is essential that individuals with type-1 diabetes alter their insulin and nutritional needs in order to ensure safe exercise because exercise increases insulin sensitivity (Weltman et al., 2009). Insulin sensitivity

defines how sensitive the body is to the effects of insulin (The Global Diabetes Community, 2015). If insulin and carbohydrate consumption are not appropriately adjusted then hypoglycemia can occur (Weltman et al., 2009). Furthermore, those with type-1 diabetes must not have complications and must ensure that their blood glucose is under optimal control before participating in exercise (Weltman et al., 2009). The benefits of exercise are numerous. Many studies have shown that exercise can improve blood cholesterol levels by lowering low density lipoproteins and increasing high density lipoproteins as well as decreasing triglyceride levels (Steppel & Horton, 2003). Also, regular exercise results in a lower heart rate, which lessens the amount of work performed by the heart (Steppel & Horton, 2003). Furthermore, a reduction in both total abdominal fat and subcutaneous fat has been associated with exercise training (Irving, Davis, Brock, Weltman, Swift, Barrett, Gaesser, & Weltman, 2008). Lastly, physical activity has been shown to increase self-esteem and improve quality of life (Steppel & Horton, 2003). Individuals with diabetes can benefit from exercise just as individuals without diabetes, but they must monitor their blood glucose levels to prevent hypoglycemia, hyperglycemia, and ketosis.

Also, it is necessary that individuals with type-1 diabetes manage their diet in order to control the disease (Burr, Shephard, & Riddell, 2012). Physical activity can help manage type-1 diabetes. In fact, physical activity helps inhibit weight gain as well as cardiometabolic disorders by working to increase daily energy expenditure (Brazeau et al., 2012). Furthermore, physical activity influences body composition, and it particularly effects android fat mass build-up (Brazeau et al., 2012). Burr et al. state that “regular PA has a positive effect on overall health in individuals with type 1 diabetes through

modification of elevated comorbid risk factors” (2012, p. 533). In fact, the Canadian Diabetes Association guidelines emphasizes the importance of managing diabetes with physical activity since it plays a major role in improving cardiorespiratory fitness and psychological status (Burr et al., 2012). While physical activity can be beneficial in helping to manage type 1 diabetes, physical activity can also lead to adverse events such as exercise induced hypoglycemia or hyperglycemia. Therefore, many individuals with type-1 diabetes do not exercise because they are afraid that exercise will lead to adverse effects (Brazeau et al., 2012). Hypoglycemia and other adverse effects can be prevented by monitoring blood glucose levels before and during exercise as well as providing carbohydrate sources when necessary (Tansey et al., 2006). Also, those who use insulin injections must make sure not to inject insulin into a limb that will be heavily utilized during physical activity because this would cause insulin to be absorbed at an increased rate and thus result in exercise-induced hypoglycemia (Steppel & Horton, 2003). Another benefit of exercise in individuals with type-1 diabetes includes preventing weight gain. Weight gain is associated with intensive insulin therapy as well as being sedentary (Brazeau et al., 2012). Therefore, it is essential to develop an exercise plan to prevent weight gain. Exercise also provides beneficial effects in body composition (Irving et al., 2008). In fact, a study revealed that high-intensity exercise training resulted in reduced total abdominal fat, abdominal subcutaneous fat, and abdominal visceral fat (Irving et al., 2008). In a study that investigated physical activity and body composition among adults with type 1 diabetes, it was found that individuals that were more physically active had lower BMI as well as a lower percentage of total and truncal fat mass (Brazeau et al., 2012). Furthermore, the study discussed that individuals with type-1 diabetes who

participated in a more active lifestyle were related with a healthier weight and body composition compared to sedentary individuals with type-1 diabetes (Brazeau et al., 2012). All in all, the study showed an association between high levels of physical activity and a better body composition profile in adults with type 1 diabetes (Brazeau et al., 2012).

Individuals with type-1 diabetes are usually younger, leaner, and more physically active than those individuals with type 2 diabetes, but the risk of coronary artery disease seems to be comparably high (Burr et al., 2012). The amount of glycemic control highly predicts the risk for cardiovascular events. In fact, an increased risk is related to glycosylated hemoglobin levels above seven percent. (Burr et al., 2012). Nadeau and colleagues “T1D is well known to cause premature CVD, shortening average lifespan despite modern therapies.” (2013, p. 517). Physical activity has been proven to improve cardiorespiratory fitness and improve longevity. Burr et al. (2012) found that all-cause mortality rates that spanned a seven-year period were around 50% lower in individuals with type-1 diabetes who recorded approximately seven hours of purposeful walking a week compared to those who reported less than seven hours. Thus, it is essential to monitor physical activity levels for individuals with type-1 diabetes because it not only helps manage type-1 diabetes but it improves cardiovascular fitness and quality of life.

The research regarding management for type-2 diabetes is extensive and ongoing. While the management for type-1 diabetes continues to be investigated, there is limited information on the benefits of physical activity on individuals with type-1 diabetes. Exercise along with diet and medication are recommended ways to manage type-2 diabetes (Weltman et al, 2009). Exercise is a recommended form of management for

type-2 diabetes because it has been shown to increase insulin sensitivity (Santeusanio et al., 2003). The effects of physical activity on body composition have been examined in individuals without diabetes and type-2 diabetes. The effects of physical activity on body composition in type-1 diabetes as well as helping to manage the disease along with insulin need to be explored in greater detail.

The purpose of this study is to determine the relationship between physical activity and body composition in individuals with type-1 diabetes. It is hypothesized that both males and females with type-1 diabetes will have better body composition profiles specifically body mass index, percent body fat, waist circumference, and waist-to-hip ratio associated with increased levels of physical activity.

## METHODS

### **Participants**

Participants include 5 male and 5 female participants with type-1 diabetes ranging from 16-22 years of age. The average age of the males was 17.06 years of age, and the average age of the females was 20.44 years of age. The participants were recruited by word of mouth around the TCU campus and from a diabetes summer camp in the Texas area.

### **Apparatus**

A Hologic dual-energy X-ray absorptiometry (DEXA) assessment will be performed on each individual to collect data for body composition specifically body mass index and percent body fat. DXA is considered a gold standard measurement of body composition (Fowke & Matthews, 2010). Furthermore, DEXA is one of the most accurate ways to measure body composition (Rieken et al., 2010). In order to determine

the level of physical activity for participants, an Actigraph GT3X accelerometer will be used.

### **Procedure**

Participants reported to the Physical Activity and Disability Lab in the TCU Rickel building one time. The participants removed their shoes, and their weight was taken in pounds using a seca model 869 floor scale. The scale was tapped and once zero was displayed on the screen the subject stepped on the scale. The weight of the subject was then recorded. Then their height was measured in inches using the height seca model 0123. Additionally, their waist circumference and hip circumference were measured to the nearest inch using a tape measurer. The participants were then asked to remove any metal and their insulin pump if they were wearing one. The DXA was calibrated according to the user's manual prior to each scan. The examination and the purpose of the examination were explained to the subject. The DXA was used to assess the participant's body mass index and percent body fat specifically regional body fat. On the computer, the start button was selected and then the turn off computer button was clicked. After the computer was shut down, the X-ray enable key was turned clockwise to allow X-rays to be produced. The computer power button was selected. When the QDR login screen appeared, the QDR icon was double clicked. The X-ray table turned on, and the technician logged into the integrated survey information system to begin the examination (CDC, 2007). The subject was asked shared exclusion questions. The shared exclusion questions include the following: do you have pacemaker or automatic defibrillator, and are you currently pregnant (CDC, 2007). Then the perform exam button was selected. The patient button was selected and the ID number of the patient from the ISIS screen

was entered into the field next to the name of the patient and the OK button was clicked. The weight, height, and date of birth of the subject were entered. If the weight of the participant was over 300 pounds, they were not included in the study due to the weight limit of the DEXA the table. The participants then answered safety exclusion questions before the computer concluded whether or not the participant was excluded from the examination. The initials of the technician were entered into the operator field and then ok was selected. In the scan selection screen, the total body scan was selected. It was ensured that the table scan area was clear of objects that could interfere with table movement before the subject was positioned on the scan area. The on switch on the control panel was pushed in order to allow the C-arm to move to the far left and extend the table out, which made it easier for the subject to get on or off the table. The subject was helped onto the table. The subject was asked to lie on his or her back with their head to the right within the scan area, which is outlined in white. The center switch was pressed on the control panel, which moves the C-arm to the center of the table. It was ensured that the subject was in the center of the scan area using the center lines at the head and foot of the table as a guide. The technician stood at the foot of the table to ensure the subject was lying straight on the table. Once the technician guaranteed the subject was lying straight on the table, the subject was strapped in by the technician with one strap above their knees and one strap around their ankles. The subject was instructed to remain motionless with eyes closed during the entire scan. The technician then proceeded to start the scan. If the subject was incorrectly positioned, then the reposition scan button was selected to stop the scan and begin again (CDC, 2007). The scan lasted around six to eight minutes. When the scan was complete, the exit exam window was

displayed, and the participants were given a report of the findings of the DEXA (CDC, 2007). After the examination was complete, the X-ray enable key will be turned counterclockwise into the off position (CDC, 2007).

After the DEXA scan is complete, the physical activity of each participant was measured using an Actigraph GT3X accelerometer, a “piezoelectric sensor-based monitor” (John & Freedson, 2012, p. 87), over ten days. The Actigraph GT3X measures static accelerations and provides inclinometer output. The Actigraph GT3X is triaxial; therefore, it is able to measure motion data on three axes. The GT3X uses vector magnitude data from the three axes and assigns a number from zero to three to determine whether an individual is not wearing the monitor (0), standing (1), lying (2), or sitting (3) (John & Freedson, 2012). The data acquired from the Actigraph GT3X accelerometer will show the length and intensity of physical activity, and it will be time-stamped. The voltage produced by the sensor increases intensity and is “digitized, rectified, and the directions (vertical, antero-posterior, and mediolateral axes) of the acceleration are determined using 12-bit ADC (sampling rate= 30 Hz.) and phase demodulation techniques” (John & Freedson, 2012, p. 88). The signal is then filtered at a bandwidth of .25 to 2.5 Hz, which means the acceleration signal is weakened as the frequency of acceleration peaks drops outside the range of .25 to 2.5 Hz. Because most human movements falls within the range of .25 to 2.5 Hz, this bandwidth is chosen so the filter could possibly exclude high frequency vibrations (John & Freedson, 2012). The process was repeated 30 times each second (30 Hz), and the resulting one second value was divided by four and added to the activity value acquired over the entire specified 15 s timespan (Esposito, MacDonald, Hornyak, & Ulrich, 2012). Pfeiffer et al. stated that

sudden unpredictable burst of activities occur in children; as a result, the 15 s timespan was chosen for this study (as cited in Esposito et al., 2012). The participants wore an elastic belt with a monitor for all hours of the day except during activities such as swimming, showering or bathing, sleeping, forgetting to put on the monitor, taking it off due to it being uncomfortable, or any other reasons for removal. The elastic belt with the monitor was worn around the ankle. Monitors were worn for ten days. The monitors were returned and the data was downloaded via Actigraph reader interface unit and affiliated software for analysis (Esposito et al., 2012).

### **Design and Analysis**

The present study is a 3 x 2 between groups design for type-1 diabetes, gender, and physical activity. The independent factors are type-1 diabetes, gender, and physical activity. The dependent factors include body mass index, percent body fat, waist circumference, and waist-to-hip ratio. The dependent measure of body composition was determined using the waist circumference and hip circumference measurements. Also, body mass index and percent body fat were assessed using the DXA. First, descriptive statistics were conducted in order to describe the sample population. The statistics included the mean and standard deviations for the age, height, weight, BMI, percent body fat, and waist circumference for males and females. Independent t-tests were conducted for the preliminary analysis to compare males and females of the sample. The two groups were found to be significantly different. As a result Pearson correlations were run by sex. For the Pearson correlation, moderate to physical activity was compared to each of the following: body mass index, percent body fat, waist circumference, and waist-to-hip ratio. The alpha level was set at .05 for all analyses.

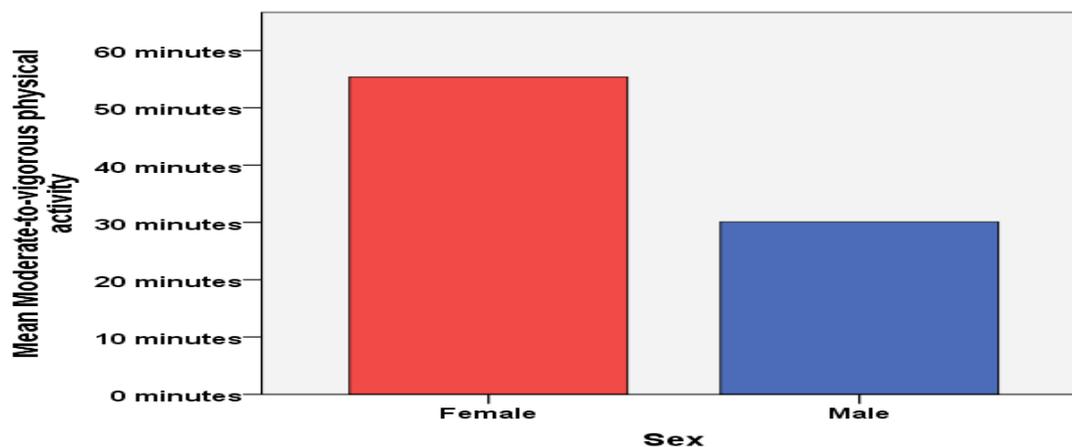
## RESULTS

The mean values  $\pm$  standard deviation for age, height, weight, body mass index, percent body fat, and waist circumference for the ten participants are displayed in table 1.

Descriptive Statistics		
<u>Variables</u>	<u>Men</u> N=5	<u>Females</u> N=5
Age (years)	$17.06 \pm 1.19$	$20.44 \pm 1.52$
Height (in)	$68.07 \pm 2.08$	$64.39 \pm 1.35$
Weight (lbs)	$169.72 \pm 43.84$	$144.04 \pm 22.10$
BMI ( $\text{kg}/\text{m}^2$ )	$29.07 \pm 5.04$	$24.39 \pm 3.13$
Percent Body Fat	$23.44 \pm 9.35$	$33.98 \pm 6.07$
Waist Circumference (in)	$33.26 \pm 6.07$	$30.44 \pm 4.23$

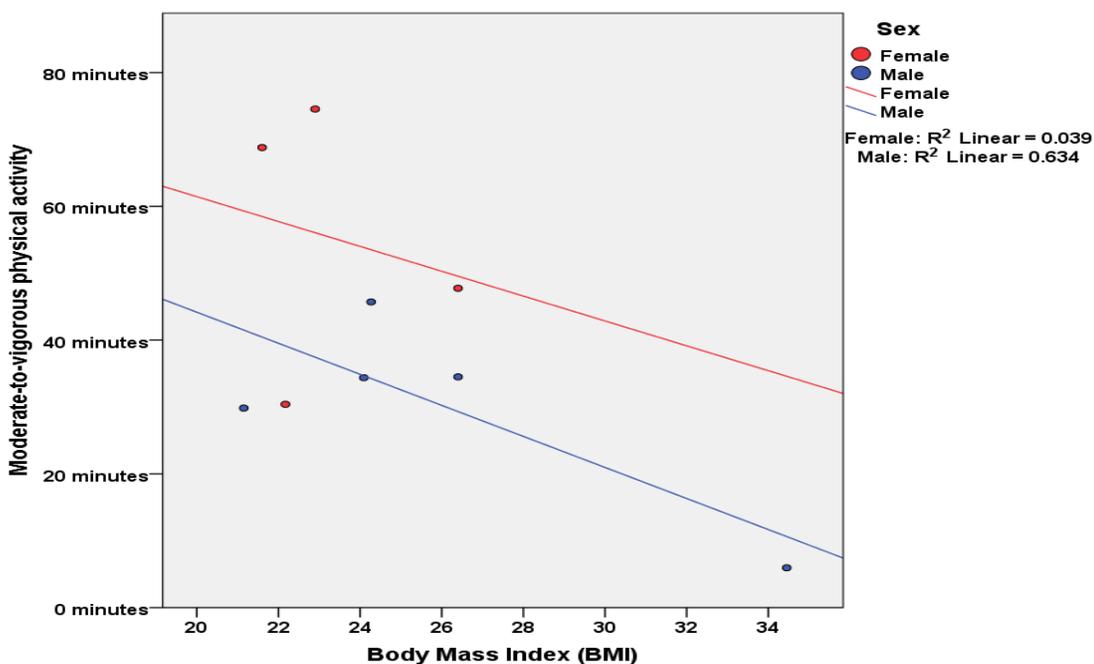
The average amount of moderate-to-vigorous physical activity per day for males and females is shown in figure 1. The females are getting more physical activity than the males but they are not meeting the recommended 60 minutes of physical activity per day. The males are barely exercising for 30 minutes a day. The relationship of this average amount of moderate-to-vigorous activity and the body composition components is examined in the upcoming graphs.

**Figure 1. Average Physical Activity Per Day for Males and Females**



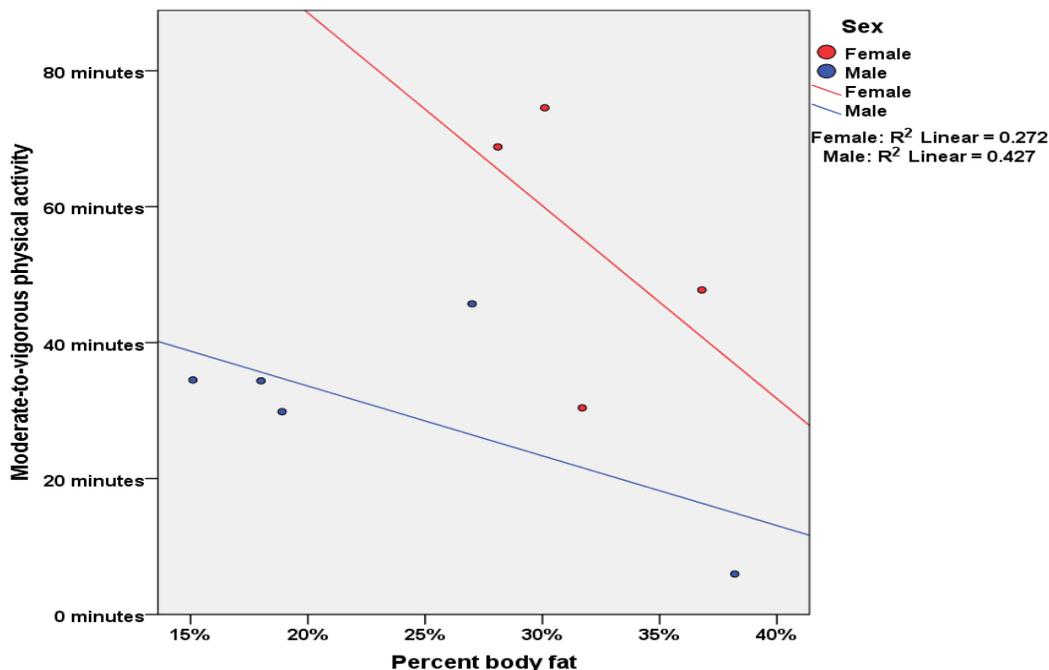
The Pearson correlation moderate-to-vigorous physical activity and body mass index for males and females demonstrated an association of higher body mass index with lower amounts of physical activity. As indicated by graph 1, the relationship for males was strong with a  $R^2$  value of 0.634 ( $>0.5$ ). The relationship for females was not strong as indicated by the  $R^2$  value of 0.039 ( $<0.5$ ).

**Graph 1. Physical Activity and Body Mass Index**



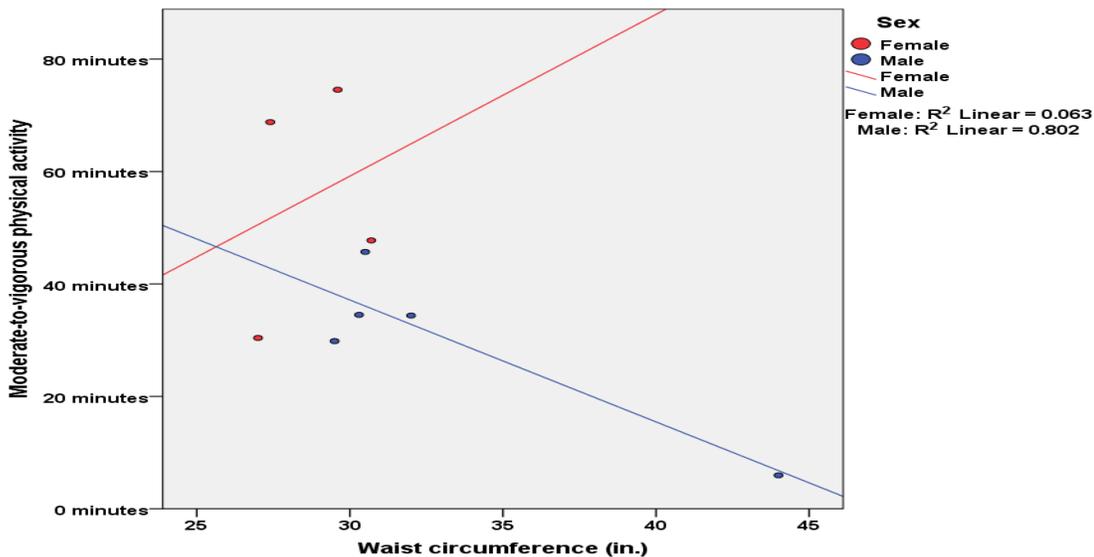
The Pearson correlation examining moderate-to-vigorous physical activity and percent body fat indicated an association of higher percent fat with lower amounts of physical activity (graph 2). This relationship for males was not strong as shown by an  $R^2$  value of 0.427 ( $<0.5$ ). A strong relationship was not seen for females as demonstrated by an  $R^2$  value of 0.272 ( $<0.5$ ).

**Graph 2. Physical Activity and Percent Body Fat**



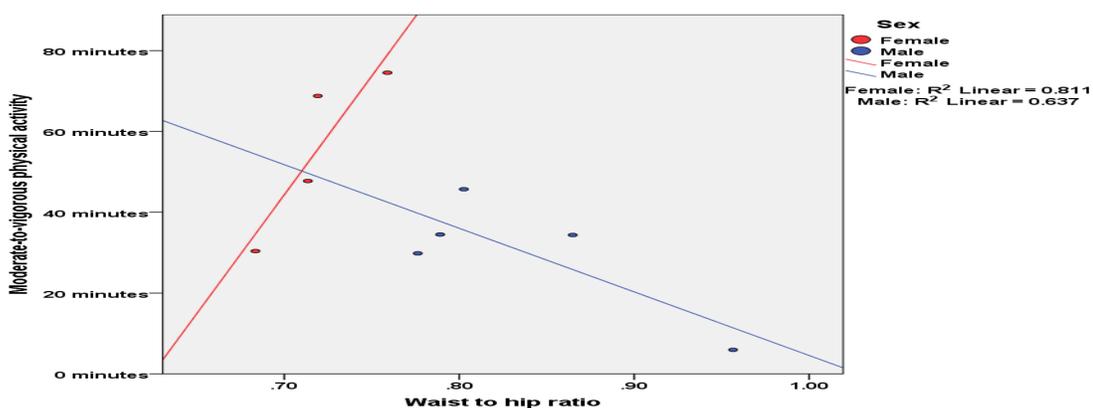
The Pearson correlation comparing the relationship between moderate-to-vigorous physical activity and waist circumference demonstrated an association with a larger waist circumference and decreased amounts of physical activity for males (graph 3). For males, this was a strong relationship as indicated by the  $R^2$  value of 0.802 ( $>0.5$ ). There was also a negative correlation for waist circumference and moderate-to-vigorous physical for males as shown by a p value of -.896. This value was statistically significant because of the alpha value of .04 ( $<0.05$ ). The negative correlation means that for males as waist circumference increases that was associated with lower amounts of physical activity. For females, the t-test indicated that as waist circumference increased that was associated with increased physical activity. The  $R^2$  value was 0.063 ( $<0.5$ ) indicating that this was not a strong relationship.

**Graph 3. Physical Activity and Waist Circumference**



The Pearson correlation examining the relationship between moderate-to-vigorous physical activity and waist to hip ratio demonstrated an association between increased waist to hip ratio and lower amounts of physical activity for males (graph 4). According to the  $R^2$  value of 0.637 ( $>0.5$ ) for males this was a strong relationship. For females, the t-test showed an increase in waist to hip ratio was associated with higher amounts of physical activity (graph 4). This was a strong relationship as well as indicated by the  $R^2$  value of 0.811 ( $>0.5$ ) for females.

**Graph 4. Physical Activity and Waist-to-Hip Ratio**



## DISCUSSION

The results support the hypothesis that increased levels of physical activity will be associated with better body composition profiles for males and somewhat for females. For males, more physical activity was associated with lower BMI, lower percent body fat, a smaller waist circumference, and a smaller waist to hip ratio. The relationships were all strong for males except for physical activity and percent body fat. Also, the only statistical significance was found with the negative correlation between physical activity and waist circumference in males. According to the physical activity data collected from the accelerometers, males are not meeting the recommended amounts of physical activity on average per day. Despite this fact, males still see improved body composition profiles with more exercise. Waist circumference and physical activity is statistically significant in males; therefore, this is a relationship that we can rely on.

On the other hand, with females there was an association with higher amounts of physical activity and lower BMI and percent fat, but neither of these relationships were strong. It was surprising that in females an increased waist circumference and waist to hip ratio were both associated with higher amounts of physical activity. This was unexpected because females usually have a smaller waist and larger hips because females tend to carry their fat around their hips. Also, a larger waist circumference is associated with more fat around the waist. When fat is located around the waist compared to the hips that is associated with visceral fat, fat around the organs, which is bad for health. The more visceral fat and the higher waist circumference increases the risk for being overweight or obese. Therefore, it is unexpected that as both waist circumference and waist-to hip ratio increased that was associated with more physical activity in females. The relationship

between waist circumference and physical activity was not strong in females, but the relationship between waist to hip ratio and physical activity was strong. These unexpected results could be due to the fact that the small sample size of five women are just genetically predisposed to having smaller waist and happen to not participate in high amounts of physical activity. This will definitely have to be explored with a larger sample size. In a study conducted by Brazeau and colleagues (2012), they measured physical activity of 75 individuals without diabetes and 75 individuals with type-1 diabetes to determine the association of physical activity and body composition. Similar to the results of this study, it was found that in both groups being physically active was associated with a better body composition profile and better body mass index (Brazeau et al., 2012). This study showed this association for males, but it was not exclusively seen for females especially for waist circumference and waist-to-hip ratio as they compared with physical activity level. Brazeau's (2012) study utilized a control group and a larger population size, but the association of physical activity and body composition in individuals with type-1 diabetes could be enhanced by including more sedentary individuals with type-1 diabetes in the sample size.

Overall, males and females both saw an association with higher amounts of physical activity and lower BMI and percent body fat as seen in other studies. This was expected and hopefully can be explored more with a larger sample size in order to examine how significant an effect physical activity has on the body composition of individuals with type-1 diabetes. Furthermore, the big question that can be explored is whether or not physical activity should be recommended as a form of management for type-1 diabetes along with insulin. As discussed earlier, physical activity has many health

benefits and can improve quality of life as well as prevent weight gain for individuals without diabetes and type-2 diabetes. Therefore, the effects of physical activity on individuals with type-1 diabetes must be studied in greater depth.

### **Limitations and Future Directions**

There are a few limitations for this study that include the small sample size and the lack of a control group. The sample size was an issue for the strength of our relationships. Also, it would have benefitted to have a large sample size to explore the comparison of waist circumference and physical activity level in females in greater depth since it was not an expected result. A control group would have allowed a comparison of the improvements in body composition profile in individuals with type-1 diabetes and those without diabetes to see how great of an effect physical activity has on body composition profiles. Lastly, in order to examine the effects increased physical activity levels have on improving the body composition of individuals with type-1 diabetes, a study could be conducted that implements an exercise program for individuals with type-1 diabetes. The individual's body composition and physical activity levels would be assessed before commencing the program and then assessed following the program to see the effect physical activity has on body composition. This is an area that needs more research since individuals are always looking for new ways to treat and manage type-1 diabetes. Hopefully, through research physical activity can be found as a method to help manage type-1 diabetes and improve the overall health of these individuals.

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