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THE RELATIONSHIP BETWEEN BODY COMPOSITION AND CARDIORESPIRATORY FITNESS OF FEMALE COLLEGIATE STUDENTS WITH SIMILAR ACTIVITY LEVELS

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ABSTRACT

THE RELATIONSHIP BETWEEN BODY COMPOSITION AND CARDIORESPIRATORY FITNESS OF FEMALE COLLEGIATE STUDENTS WITH SIMILAR ACTIVITY LEVELS

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Body image is a huge topic in our society, and while people are being encouraged to "love their bodies," it would also be reassuring if they were able to understand the science of their body and just how much ones' body composition does affect their health. One way to measure someone's fitness level, more accurately known as their cardiorespiratory fitness, is by calculating their maximal oxygen consumption ($VO_{2\ Max}$). To further understand the extent to which one's body composition effects their fitness levels, 10 collegiate students were placed in a Bodpod to measure their body composition in terms of body fat percentage (% BF) and fat-free mass percentage (FFM%). Following that, a maximal exercise test was conducted to calculate their $VO_{2\ max}$ values that are an indication of cardiovascular fitness levels. The values of body composition and VO_{2max}

values were analyzed to find any correlation between the two components. The ANOVA between groups was done to find no significant difference in the VO_2 max values of those with a BMI lower and higher than 25.

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CHAPTER 1

INTRODUCTION

Stereotypes are all around us, whether people are being judged based on their sex, race, or even just weight. One common judgment is that overweight individuals are lazier than individuals who fall within the normal body mass index range (BMI). Additionally, people assume those who weigh less are healthier and more fit than those who weigh more. But, how accurate is this judgement? Does an individual's body composition directly correlate to their cardiorespiratory fitness?

One way to measure someone's fitness level, more accurately known as their cardiorespiratory fitness, is by calculating their $VO_{2\ max}$ (Danilo R. Bertuccil, Nuno MF. Soisa, Guilherme B. Pereira, et. Al. 2016). The $VO_{2\ max}$ is defined as the greatest amount of oxygen that can be taken up and transported to the body's tissues and muscles during exercise, which in turn defines the cardiorespiratory system's limits (Hawkins,2007). The best way to measure one's $VO_{2\ max}$ is by conducting a maximal exercise test. The most commonly used exercise test to determine maximal aerobic capacity is the Bruce Protocol. This involves 3-minute stages with an increase in speed and gradient of the treadmill every stage. In the study conducted by Hawkins and his colleagues in 2007, the data suggested that even if the work rate of the exercise activity were to increase, the $VO_{2\ max}$ value would still remain constant.

Oxygen is essential for everyday life. Without it, our cells would die, causing our organs to stop working, and eventually lead to death. When one exercises, the demand for oxygen increases, as the muscles involved begin to require more oxygen in order to maintain the workload. With this increasing demand for oxygen, one's body has to respond by supplying the body with sufficient oxygen. The body is able to do this by numerous techniques. Initially, one's breathing increases in order to take in a greater volume of oxygen. Then, this oxygen needs to make its way to the muscles through the hemoglobin in the blood. To increase the flow of blood to the muscles, the body's blood vessels will dilate allowing more blood to rush to the muscles. The heart will also start contracting more quickly, increasing heart rate, in order to also meet the increased oxygen demand to the muscles (Kenney, Wilmore, Costill,& Osterberg, 2015). With more training, one's body is able to take these necessary steps more efficiently than a sedentary person (Sports Training Adviser 2016). So this value allows the differentiation between people who have high cardiovascular fitness levels with those who have low cardiovascular fitness levels. VO_{2max} values are not necessarily a factor of one's body composition, but rather how much of an influence does body composition have on one's cardiovascular fitness levels.

Body composition describes the percentage of fat, bone and muscles in the human body. It can be measured through numerous methods, such as: body mass index (BMI), skinfolds, dual energy x-ray absorptiometry (DEXA), bioelectrical impedance analysis (BIA), and Bodpod. BMI is the most common method used, as it is quick and easy. BMI results in taking the body weight in kilograms and dividing it by the height in meters squared. This method is used to classify the individual's risk for cardiovascular disease. Values around 18-24 are considered average; values of 25 to 29.9 are considered overweight; values over 30 are considered obese. The larger the number, the higher the risk for cardiovascular disease. This is a good initial technique to get a quick estimate of risk concerning cardiovascular disease. However, the downfall to this technique is that it does not take into consideration whether the weight is composed of mostly fat or muscle. A higher percentage of muscle or fat-free mass (FFM) is preferred but muscles weighs more than fat. Skinfolds are an inexpensive method and provide more informative data about one's body composition. It observes how much fat one has stored on their body. The theory behind this method is that 1/3 of one's fat is stored subcutaneously, so if you are able to identify that value, you can easily calculate the body's total body fat. This is done by pinching the skin at different locations of the body (triceps, chest, suprailiac, abdominal, thigh, midaxillary, and subscapular), and using a skinfold caliper to measure the thickness of the fold that contains your skin and the underlying fat layer. This can be a very accurate method of calculating percent body fat if done accurately. DEXA is now considered the gold standard for calculating body fat mass and fat free mass as it uses an x-ray to locate all the fat stored in the body. However, it is very expensive to use. BIA is another quick method and commonly used in the gym setting. The BIA sends a low level electrical current from one end of the body to the other. When the electrical current moves through the muscles, it is very quick due to it containing over 70% water, whereas when it moves through the fatty areas of the body, it slows down tremendously. Fat is not as good of a conductor as muscles because muscles have a low percentage of water. By measuring the opposition of flow of the electrical current through the body, an estimate of total body water can be calculated, which in turn allows the estimate of the body's fat free mass and fat mass. The last method used to measure body composition is the Bodpod, which is an air displacement plethysmograph. It uses the body's density to determine how much of the body is fat vs fat free, by calculating body mass (weight) and volume using the equation of

Density= mass/volume (Ybefit 2018).

The purpose of this study was to explore the extent that body composition might have on cardiovascular fitness, and if it is possible to have a high BMI while still maintaining an average or about average $VO_{2\ max}$ value. The null hypothesis is that there is no significant difference in the cardiorespiratory fitness of individuals with a higher body composition (BMI > 25 or % BF over 26.7) when compared to individuals with lower body composition (BMI < 25 or % BF under 26.7).

CHAPTER 2

METHODS

2.1 Subjects

Twenty-two subjects were interested in participating in the study. Seven of the volunteers were males, and therefore could not participate in the study. Four of the female participants withdrew from the study prior to being tested, and one took part in the test; however, inaccurate techniques were used during the test, so her results were not used. Therefore, ten participants between the ages 17-26 years took part in this study. Five of the subjects had a BMI under 25, and five with a BMI over 25. The subject pool with a BMI under 25, had an average height of 65.7 ± 3.9 inches, weight average of 62.6 ± 7.1 kg, and a BMI average of 22.7±1.2. The subject pool with a BMI over 25, had an average height of 64.4 ± 3.1 inches, weight average of 71.1 ± 9.2 kg, and a BMI average of 26.8±1.0. All the participants live active lifestyles and exercise regularly, either doing aerobic exercises or weight training.

All participants were enrolled students at The University of Texas at Arlington and volunteered to participate in this study. Before participating, each participant was informed of the procedure and were informed that they could stop the study whenever they wished. Before the study began, they all signed an informed consent form. Faculty sponsor for this project was Dr. Judy Wilson, who advised the study. Each participant completed a questionnaire prior to the study beginning which included their daily activity levels and medical history to ensure that participants were of good health with no health problems that could affect the results of the study. Participants with any medical history concerns were not allowed to participate in the study. Prior to onset, participants were instructed to refrain from drinking water, eating, and exercising two hours before the trial began, to insure accurate results. Scheduling of the test was dependent on the student's school schedule and training schedule, so that no strenuous physical activity took place two hours prior to the study.

2.2 Experimental Design

Participants were asked to report to the UTA Kinesiology Research room located in the Maverick Activity Center in room 153 on one occasion. After they read and signed the consent form, the procedure includes two parts: collecting their body composition data and the maximal exercise test portion.

2.2.1 Body Composition

The participants changed in to compression shorts made of spandex and/or lycra and a sports bra, which were provided to the participants if they did not have their own. Participants were then asked to stand on the scale on the floor to obtain a body weight that was recorded by the Bodpod software. A hair cap was placed on the participants, which covered all their hair and their ears. They then sat in the seat of the Bodpod and were asked to place their hands on their knees, to close their eyes and their mouth, and just breathe from their nose while trying not to move. The door was then closed, and two measurements were taken, each lasting about a minute. After their measurements were taken, they were asked to change into what they preferred to wear for the maximal exercise test portion.

2.2.2 Maximal Exercise Test

A Polar heart rate monitor was attached to the chest of each participant to allow for accurate measurement of their heart rate. This signal was sent to a watch attached to the treadmill handrail and the heart rate was read from there. The participants then stood on the treadmill while the headgear was fitted to their head in order to hold the mouthpiece in place. The mouth piece, similar to what is used for snorkeling, was used along with a nose clip to ensure that exhaled air was collected in the metabolic cart during the exercise. That allowed the calculation of their oxygen consumption, which is a measure of aerobic fitness. Rate of perceived exertion score (RPE) was taken at the end of each workload with the rating from 6 (rest) to 20 (maximal exercise) as a subjective way to quantify the difficulty of the workload to the participant. The Bruce Protocol test was the maximal exercise test used in this study, which increased the treadmill speed and elevation every three minutes until the participants could no longer go any further. Because the participants had the mouth piece in, they need to communicate through hand signals. A “thumbs up” indicated they were feeling good and able to continue exercising, a “waggle” of the hand indicated they were starting to feel tired and would not be able to last much longer. When they felt they absolutely could not go any longer, they were instructed to grab onto the treadmill handrail. The test was slowly stopped anytime the participants could no longer continue due to pain, fatigue, or any other health issue (Wood 2008). At that time, the time was stopped (Marshall M, Coe D, Pivarnik J, 2013). Again, the heart rate was recorded at the end of every stage, and RPE of each participant was recorded at 15 seconds before the end of each stage (Suminski R, Ryan N, Poston C, Jackson A, 2012). When the test ended, the participants went into recovery mode, which consisted of just walking at a 0% gradient on the treadmill until they felt recovered and their heartrate was below 120 bpm.

2.3 Instrumentation

To measure the participants weight and body composition, the BodPod was used. To conduct the maximal exercise test, the Parvo treadmill and metabolic cart were used to collect VO_2 values. Heartrate was tracked using a Polar heart rate monitor. The Borg Rate of Perceived Exertion scale was used to quantify the perceived exertion during the maximal exercise test.

2.4 Statistical Analysis

Variables that were used for analysis included heart rate, % body fat, body mass index (BMI), and $VO_{2\ max}$. A correlation coefficient was calculated to analyze the relationship between $VO_{2\ max}$ and body composition. The alpha level for significance was set at $p < 0.05$ to test for significance. One-way between groups ANOVA was evaluated using SPSS 24.0.

Figure 2.1: Participant in Bodpod

BORG SCALE	
Rating of Perceived Exertion	
6	
7	Very very light
8	
9	Very light
10	
11	Fairly light
12	
13	Somewhat hard
14	
15	Hard
16	
17	Vary hard
18	
19	Very very hard
20	

Figure 2.2: BORG RPE Scale

Figure 2.3: Parvo Treadmill

Figure 2.4: Participant Doing Maximal Exercise Test with Head Gear and Mouth Piece

CHAPTER 3

RESULTS

This study was made up of a total of ten female participants, who were all Kinesiology students from the University of Texas at Arlington. All ten participants had their body compositions calculated using the Bodpod and then they all completed the Bruce Protocol for this experiment. The mean age for the group that had a BMI under 25 (group 1) was 20± 1.8 years, and the mean age for the group with the BMI over 25 (group 2) was 21 ± 3 years. The mean height for group 1 was 65.7 ± 3.9 inches, and the mean height for group 2 was 64.4 ± 3.1 inches. The mean weight for group 1 was 62.6 ± 7.1 kg, and the mean weight for group 2 was 71.1 ± 9.2 kg.

Table 3.1 : Demographic Variables of Group 1 (BMI < 25)

	Age (years)	Height (inches)	Weight (kg)
Mean	20	65.7	62.6
S.D.	1.8	3.9	7.1

Table 3.2: Demographic Variables of Group 2 (BMI >25)

	Age (years)	Height (inches)	Weight (kg)
Mean	21	64.4	71.1
S.D.	3.0	3.1	9.2

The Bruce protocol consists of 10 stages of 3 minutes each. As the participants progressed from one stage to another, the speed increased by 0.8 mph and the slope increased by 2%. The participants kept walking and/or jogging on the treadmill until they reached exhaustion. The mouth piece and metabolic cart was collecting the amount of oxygen consumed and the amount of CO_2 produced by the participants in order to calculate VO_2 variables and eventually VO_2 max.

Table 3.3: VO_2 of Participants When Comparing BMI

Group	VO2 Max Value (ml/kg/min)
BMI Under 25	38.1 ± 4.22
BMI Over 25	38.2 ± 4.08

Table 3.4: VO_2 of Participants When Comparing % BF

Group	VO2 Max Value (ml/kg/min)
% BF Under 26.7	36.96 ± 4.05
% BF Over 26.7	39.32 ± 4.83

To test for significance, the alpha level was set to $\underline{p< 0.05}$ and the data was analyzed using a one way between groups ANOVA, SPSS 24.0. The findings of the analysis revealed there was no significant difference in cardiorespiratory fitness levels between people with a BMI under 25 and a BMI over 25, or with people with a % BF under 26.7 and a % BF over 26.7. The F- statistic and p-value for this experiment were: $F [1,8] = .001$, $p=.979$ when comparing BMIs, and $F [1,8]= .702$, $p=.427$ when comparing % BF. Based on the results of the analysis, the null hypothesis was accepted because there was no significance found.

CHAPTER 4

DISCUSSION

The ANOVA test revealed no significant difference in the mean VO_2 Max of the group with a BMI under 25 and the group with a BMI over 25. There was also no significant difference in the mean VO_2 max of the group with a percent body fat under 26.7 and the group with a percent body fat over 26.7. This leads to the support that body composition does not necessarily have a direct effect on cardiorespiratory fitness if one is active.

One reason to explain why no difference was found when comparing the groups based on percent body fat, could be because 26.7 % BF still falls under the average range for percent body fat. The reason 26.7 % BF was used as the criteria was because based on the 10 individuals who participated in the study, 26.7 was the median number, and thus the only way to equally split the participant into two groups. The average range for percent body fat for females of this age is 23-29.9%. Had 29.9% BF been used to split the participants into two groups, only two participants would have fallen in the group with a percent body fat over 29.9%.

This also raised another limitation in this study. The pool of participants were all active, as was the required criteria; however, using BMI as the initial criteria when recruiting the participants could be a weakness in this study. That is became BMI only looks at body weight and height, it does not take into consideration how much of the body weight is attributed to by muscle mass. As shown by the % BF results, it becomes clear that most of my participants who had a BMI over 25 were rather fit individuals who had a lot more muscle mass contributing to their total body weight.

A recommendation for the future will be to gather a pool of participants and use percent body fat as the means to distinguish the groups, rather than using BMI. It would also be effective to be more precise on what types of activities participants do to stay active, whether it involves recreational activity, weightlifting, or cardiorespiratory workouts.

Another interesting thing to explore would be to compare low activity individuals, which have a low percent body fat with a group of highly active individuals that which have a high percent body fat to see the difference in their VO_2 max values. This could further support the theory that being active while having a higher body composition can benefit the individual's cardiorespiratory fitness status and possibly offset other diseases associated with obesity.

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BIOGRAPHICAL INFORMATION

Nawal was born in Jerusalem, Palestine, but she grew up in Arlington, Texas. She began her studies at the University of Texas at Arlington (UTA) in the Fall 2014 with the hopes of earning a degree in something that would pave the way to a future in the medical field. She graduated with an Honors Bachelor of Science in Kinesiology, and a minor in Business Administration.

During her undergraduate career in Kinesiology, she was encouraged to conduct and participate in numerous research projects from multiple instructors. In the spring of 2017, Nawal conducted and presented her first research project, with a couple of colleagues, on the difference in the cardiovascular fitness of collegiate softball players and volleyball players. For her senior research project, she worked under the supervision of Dr. Judy Wilson to explore the impact body composition has on cardiovascular fitness.

Besides research, Nawal spent her time involved in student organizations on campus, where she held numerous executive positions. These included Student Government Senator and then Supreme Court Justice, Vice President of Students for Justice in Palestine, and as the Secretary of Pre-Physician Assistant Organization, which she helped start. She also taught a Freshman Interest Group class for three years where she helped freshmen transition to college and taught skills to help them be successful.

Nawal hopes to continue her education and become Physician Assistant, with a focus in Pediatrics. She also hopes to one day come back and teach at UTA as a way to show her gratitude for all the opportunities that were offered to her there.