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THE RELATIONSHIP BETWEEN BODY COMPOSITION AND FITNESS PARAMETERS

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by

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ABSTRACT

THE RELATIONSHIP BETWEEN BODY COMPOSITION

AND FITNESS PARAMETERS

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The purpose of this research study was to investigate the relationship between body composition and fitness parameters. Seven recreationally active males, age: 20.7 ± (1.1) years, height: 183.6 ± (9.2) cm, weight: 79.2 ± (9.9) kg, volunteered for this study. Body composition, aerobic and anaerobic measurements were taken and analyzed using correlational statistics. Results indicated strong inverse correlations between body fat percentage and peak power (-0.836) and body fat percentage and mean power (-0.841). There was a weak correlation between body fat percentage and total work (0.390). Overall, the lower the body fat percentage, the more muscle mass is available to produce power yielding a high correlation. There was a weak correlation (0.413) between total mass and absolute oxygen consumption. Results are supported from the literature and are good indicators of health in college-aged males.

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CHAPTER 1

INTRODUCTION

1.1 Body Composition

Body composition can simply be defined as the ratio of material that makes up the human body. The human body contains many substances, but they can be divided into two categories; fat mass and fat free mass (Bentzur, et al. 2008). The ratio of these substances is important for optimal athletic performance. Simply, the athlete needs to have certain a ratio of each, but an imbalance can be detrimental to performance. In sports, body composition relates to performance (Bentzur et al. 2008). If a person has too high of a body fat percentage, they may not be able to produce as much power, achieve as high of a maximal oxygen consumption (VO_{2max}), or meet the demands of the sport when compared to a person with a lower body fat. Monitoring body composition in sports is important to maximize performance and to monitor populations at risk for eating disorders.

Body composition can be described using the two component model which divides the body into fat mass and fat free mass. Fat mass is composed of adipose tissue. Adipose tissue is essential for insulation and storing energy in the body, but in excess can impair athletic performance and lead to adverse health risks (Venkata et al. 2004). Fat free mass is composed of the remainder of body mass including bone, muscle, and other organs. Fat free mass correlates with the amount of muscle mass a person possesses, and thus, relates to the muscular power that can be produced. Power produced relates to the amount of work a person can perform which in turn affects athletic performance (Maiejczyk et al. 2015).

Performing various activities requires different levels physical fitness. Evaluating fitness is important in order to monitor training adaptations, level of physical performance and disease risk (Vaara et al. 2012). Fitness can be separated into two categories: aerobic and anaerobic.

1.2 Aerobic Fitness

Aerobic fitness evaluates the capacity of aerobic metabolism. This is the process in which the body produces energy using oxidative phosphorylation to yield ATP (Wilmore et al. 2008). Aerobic fitness is needed to perform endurance activities. Evaluating aerobic fitness can be used to analyze different components of health, including bone mineral density and cardiovascular disease. There is a relationship between aerobic fitness and body composition that allows researchers to predict possible health outcomes (Vaara et al 2012).

It has been observed that there is an inverse relationship between body fat and maximal strength and maximal endurance. This can be explained by the more body fat a person has, the larger the portion of their body mass that is unable to produce movement. It has been found that there is a positive correlation between lean mass and maximal strength (Vaara et al. 2012). Extra adipose tissue also increases the amount of insulation in the body, making it harder for the body to dissipate heat (Wilmore et al. 2008). This affects the available exercise capacity and can cause fatigue, possibly terminating exercise earlier then an individual with less body fat.

A positive correlation has been found between maximal oxygen consumption and cardiorespiratory fitness (Vaara et al. 2012). In order to reach maximal levels, the body has to adequately perfuse the muscular tissue (Wilmore et al. 2008). It has also been shown that muscular endurance is positively correlated with maximal oxygen consumption (Vaara et al. 2012). Both muscular endurance and maximal oxygen consumption were negatively associated with body fat percentage.

A common protocol to evaluate aerobic fitness is the Bruce Protocol. The Bruce takes the participants through a series of graded stages until maximal levels are achieved. Maximal levels can be evaluated using by the following criteria: change in VO_2 less than 2.1 ml/kg/min with increasing workload, an respiratory exchange ratio (RER) greater than or equal to 1.10, a rate of perceived exertion (RPE) greater than or equal to 8 (scale of 1-10), a heart rate within ten beats per minute of age calculated max, or volitional fatigue was met (Croall et al. 2017). A positive correlation found between duration of Bruce protocol test and cardiorespiratory fitness. Further, the study found a correlation between cardiorespiratory fitness and leisure time physical activity intensity (Singhal and Siddhu 2014). Information from this study can be used to further build exercise programs in order to achieve a high intensity workout.

1.3 Anaerobic Fitness

Anaerobic power systems are used to perform short bouts of maximal exercise (Maiejczyk et al. 2015). In tests, such as the Wingate, the load placed upon the participant is established in relation to total body mass. Peak power represents the ability of muscles to produce a higher mechanical power within a short time. Mean power represents the ability of the muscles to sustain the high power output (Inbar et al. 1996). Results can be reported as absolute or relative values. Absolute values account for the whole amount of the variable produced and tends to favor those with a higher body mass. Relative values are usually reported as the variable per kilogram of body mass and favor those with a low body mass. Studies have found that there is a positive correlation between absolute power and body mass (Maiejczyk et al. 2015). Studies have shown that obese people produce a higher peak power than those with an average body mass. Power measurements are beneficial to sports that require short bursts of activity.

Throughout the literature, a relationship between body composition and aerobic and anaerobic fitness parameters has been found. Few studies have evaluated all three categories together. Thus, the purpose of this study was to investigate the relationship between body composition and fitness parameters.

CHAPTER 2

METHODOLOGY

2.1 Overview

Seven participants volunteered to participate in this study. Participants were recruited using face to face interviews. All participants were recreationally active college aged males who were students at The University of Texas at Arlington. Participants were excluded if they had prior medical conditions or if they had a musculoskeletal injury that prevented them from performing to maximal ability. All participants were educated on the purpose of the study and signed an informed consent document prior to participation.

Participants were asked to complete two lab visits. The first visit consisted of body composition measurements via the BodPod and the Wingate anaerobic test. The second visit consisted of a maximal aerobic test using the Bruce protocol. During the first visit participants completed a questionnaire that detailed height, activity level, recreational activities performed, and medical conditions that would impair testing. Body mass index (BMI) was calculated from height and weight.

2.2 BodPod

Body composition was measured using the BodPod. The BodPod uses air displacement plethysmography to determine body fat percentage. The BodPod was calibrated per the manufacturer's instructions. This test was done in the privacy of the laboratory. The participant was provided spandex shorts and a spandex swim cap. The participant was asked to change in the locker room suite located in the research laboratories. The participant was asked to void the bladder when in the locker room to prevent errors in data. The participant removed jewelry, eye wear, socks, and clothes prior to stepping on the scale and entering the BodPod. Participants were instructed to breathe normally when inside the BodPod and to refrain from excessive movement of their appendages. Predicted lung volume measurements were used. Two volume measurements were taken. If there was a deviation between the two measurements, a third volume measurement was taken. After BodPod results were recorded, participants were instructed to change back into their athletic attire to perform the Wingate.

2.3 Wingate Anaerobic Test

The Wingate Anaerobic test is designed to measure power, total work, and other anaerobic fitness parameters. The bike seat high was adjusted so that their leg had a slight bend when their leg was perpendicular to the ground. Participants were instructed to warm up at 60 revolutions per minute for between 1-2 minutes. When the participant signaled they were ready, they were instructed to pedal as fast as they could for a 3 second countdown. The resistance was then applied for the 30 seconds of the Wingate test. Participants were offered verbal encouragement via experimenters. After the Wingate was terminated, participants were instructed to lightly pedal to cool down until they felt they were ready to get off of the bike. Participants were monitored for at least 5 minutes before leaving the laboratory site.

2.4 Bruce Protocol

Upon arrival for the second visit, a heart rate monitor was attached to the participant's chest to allow the experimenter the ability to measure heart rate during the experiment. The signal was sent to a watch from which the experimenter read the heart rate. Then the participant stood on the treadmill while the headgear was fitted to their head in order to hold the mouthpiece in place. A mouthpiece was used along with a nose clip to ensure that exhaled air was collected in the metabolic cart during the exercise. This allowed the calculation of the participant's oxygen consumption (VO_2), a measure of aerobic fitness. Heart rate was taken during each workload along with a rate of perceived exertion score (RPE) with ratings from 6 (rest) to 20 (maximal exercise). The treadmill protocol increased speed and elevation every three minutes until the participant could not go any further. The participant communicated with hand signals. A "thumbs up" indicated continuing to exercise, a "waggle" of the hand, palm down, indicated not much longer. The participant was then asked to continue "another 30 seconds" or "into the next workload" prior to stopping. This allowed the researcher to collect final or maximal values. The treadmill was then sent into recovery mode and the participant was allowed to slow down while heart rate was monitored. When the participant's heart rate was below 120 bpm and they felt recovered, they were allowed to leave.

CHAPTER 3

RESULTS

3.1 Demographics

Seven recreationally active males who are students at The University of Texas at Arlington began the research study. One subject was diagnosed with an upper respiratory infection between the two trial dates thus terminating his participation. Six subjects completed the research study. Demographic data is shown in the following Table 3.

Table 3.1: Participant Demographic Data

Variable	Mean ± (St. Dev)
Age (yrs)	20.714 ± (1.113)
Height (cm)	183.6 ± (9.2)
Weight (kg)	79.245 ± (9.902)
Body Fat %	15.057 ± (6.037)
BMI (kg/m^2)	23.650 ± (1.195)

Participant's average age was 20.714 ± (1.113) years old. The average height was 183.6 ± (9.2) cm and the average weight was 79.245 ± (9.902) kg. The average body fat percentage was 15.057 ± (6.037) and the average body mass index (BMI) was 23.650 ± (1.195) kg/m^2.

3.2 Experimental Findings

Results of the Wingate Anaerobic Test and Bruce Protocol are shown in Table 3.2. Fitness parameter results below were then compared with body composition variables in correlational analysis.

Table 3.2: Results of the Wingate Anaerobic Test and the Bruce Protocol

Variable	Mean ± (St. Dev)
Mean Power/ Body Mass (W/kg)	7.238 ± (0.739)
Peak Power/ Body Mass (W/kg)	9.115 ± (1.265)
Total Work (J)	15.926 ± (2.525)
HR max (bpm)	183 ± 6.723
VO2 max (L/min)	4.243 ± 0.528
VO2 max (ml/kg/min)	52.683 ± 7.261
RPE max	18.333 ± 1.211
MET max	15.067 ± 2.055
Time max (min:sec)	12: 54 ± 1: 37

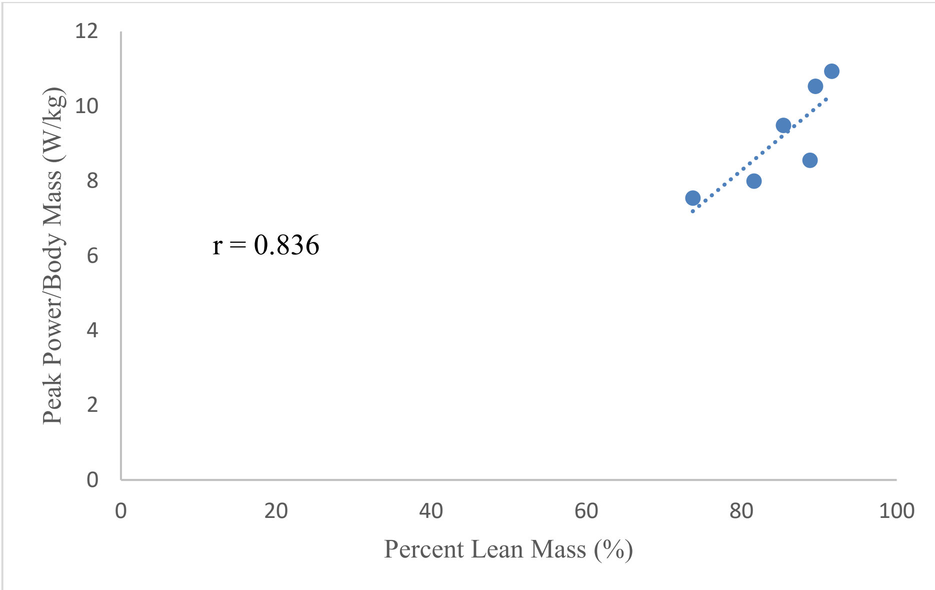
3.3 Correlational Analysis

Table 3.3: Correlational Coefficients Between Variables Collected During the Study

Variable	Correlational coefficient
Lean Mass and Peak Power	0.422
Lean Mass and Mean Power	0.774
% Lean Mass and Peak Power	0.532
% Lean Mass and Peak Power/Body Mass	0.836
% Lean Mass and Total Time	0.607
Peak Power/Body Mass and Relative VO2	0.622
Body Fat % and Peak Power (W) (PP)	-0.532
Body Fat % and Mean Power (W) (MP)	-0.336
Body Fat % and Peak Power/Body Mass (W/kg) (PP/BM)	-0.836
Body Fat % and Mean Power/Body Mass (W/kg) (MP/BM)	-0.841
Body Fat % and Total Work (J) (TW)	0.423

Table 3.3 shows correlational analysis results. Data was analyzed using excel functions. The greatest correlation achieved in this study was between percent lean mass and peak power per body mass. The relationship is visually depicted in Figure 3.1.

Figure 3.1: The Relationship Between Percent Lean Mass and Peak Power per Body Mass



CHAPTER 4

DISCUSSION

4.1 Body Composition

Body fat percentage evaluates the ratio of fat mass to fat free mass, whereas BMI evaluates the ratio of height to weight. In active males, BMI is not always a valid indicator of health, because it does not account for the ratio of fat mass to fat free mass. To demonstrate this point, data showed that participants had a body fat percentage of 15.057 ± (6.037) and a BMI of 23.650 ± (1.195) kg/m^2. For males, a body fat percentage ranging from 12.1-20% shows a moderately lean body composition that is generally acceptable for good health (REF). A BMI range from 18.5-24.9 kg/m^2 represents a normal BMI and 25-29.9 kg/m^2 represents an overweight BMI. From the results, it would seem that most participants are close to being classed as overweight, but looking at the body fat percentage data, it shows that some of the participants have a relatively low percentage of fat mass. This illustrates that evaluating body composition independent of BMI is necessary in active populations in order to account for the weight of muscle mass.

The results of this study show that there was a relationship between body composition and fitness parameters. There is a moderate inverse correlation (-0.532) between body fat percentage and peak power. Those with a greater body mass generate more power in order to facilitate rapid movements. As there is an increase in muscle mass, there also must be a higher force production in order to move the additional mass

(Maciejczyk et al. 2015). Those with more total mass tend to produce greater peak power when compared to mean power (Maciejczyk et al. 2015).

4.2 Power

The results of this study show that there was a relationship between body composition and fitness parameters. There is a moderate inverse correlation (-0.532) between body fat percentage and peak power. Those with a greater body mass generate more power in order to facilitate rapid movements. As there is an increase in muscle mass, there also must be a higher force production in order to move the additional mass (Maciejczyk et al. 2015). Those with more total mass tend to produce greater peak power when compared to mean power (Maciejczyk et al. 2015).

There is a high inverse correlation (r = -0.836) between body fat percentage and peak power per body mass. There is also a high inverse correlation (r = -0.841) between body fat percentage and mean power per body mass. This shows that the lower the body fat a participant had, the more power they were able to produce per kilogram of body weight. This is likely because those with a low body fat, have greater proportions of muscle mass available to produce power (Maciejczyk et al. 2015). Having a greater ability to produce power can help improve athletic performance in short burst activities such as sprints and power lifting. Peak power correlates more to extreme high intensity activities lasting only a few seconds, whereas mean power correlates to high intensity activities that last more than a few seconds but less than 60 seconds (Inbar et al. 1996). This correlation can be used to identify which area of training in which the athlete needs to improve. Collected data can be used to create an individual training program to optimize power production for each individual’s needs. Interestingly in this study, participants who reported performing regular weight training did not produce the most power. This may be a result of the type of lifts performed and a lack of specification with weight training. Many young males center training on desired changes in physique, which does not always translate into increased generation of power.

4.3 Heart Rate

There was a low correlation (r = 0.194) between maximal heart rate and body fat percentage. This is expected because maximal heart rate is largely age dependent (Wilmore et al. 2008). Participants of this study were aged 20.714 ± (1.113), therefore it is expected that their maximal heart rates would be similar. Prior experience performing the Bruce Protocol would potentially affect heart rate because participants would better understand the procedure and would feel more comfortable performing to maximal exertion. Repeating the Bruce Protocol may yield slightly higher heart rates, but it is still not expected for participants' heart rates to greatly vary because the variable is age-dependent.

4.4 Time

There was a moderate correlation (r = 0.607) between lean mass percentage and maximal time on the Bruce Protocol. Participants who reported participating in recreational sports such as soccer and basketball performed longer on the Bruce Protocol. This is likely because both sports require different intensities of running, and an active recovery period. This type of training interval training program elongates time until anaerobic threshold is reached and prolongs time until volitional fatigue (Wilmore et al. 2008).

CHAPTER 5

CONCLUSION

In conclusion, there is a relationship between body composition and different fitness parameters. Information from this study can be used to help improve training prior to competition. Each sport has a specific body composition that is ideal for performance. For example, a cross country skier will have a low body fat whereas a football lineman will need a greater percentage of body fat for optimal performance. Different fitness parameters can also be related to overall health and risk for cardiovascular disease. Information from this study can be utilized to evaluate the overall health of participants and used to create an exercise program to best address their health concerns.

5.1 Limitations

Limitations to this study include the number of participants. Due to time and lab restrictions, testing a large number of subjects was not feasible. In the future, a larger group of subjects should be used in order to ensure the validity of data found. Larger subject pools will also allow for a greater variation in body composition and recreational activities, allowing for a more in depth analysis of the relationship. Another possible limitation in this study was the time at which participants were tested. They were all tested between 11:00 A.M. and 2:00 P.M. This was a concise time and participants were advised to refrain from food consumptions prior to testing however, participants may have performed different activities earlier in the day that could have impact body composition measurements.

APPENDIX A

EQUIPMENT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BIOGRAPHICAL INFORMATION

Rachel Agostino graduated with an Honors Bachelor of Science in Exercise Science. She was also recognized as graduating with leadership honors. Throughout her time at The University of Texas at Arlington, she was involved in the sorority Delta Delta Delta, Society of Kinesiology Scholars, Pre-Physical Therapy Club, Order of Omega, and the Leadership Honors Program. She has served on the Delta Delta Delta and Pre-Physical Therapy Club's executive board for almost two years. She has spent numerous hours volunteering in the community, which gave her a greater appreciation of the University of Texas at Arlington's community and her peers. Rachel has enjoyed her experiences at The University of Texas at Arlington and thanks those who have helped her through her undergraduate journey.

Rachel will attend The University of Texas Southwestern Medical Center in Dallas to pursue a Doctor of Physical Therapy. Rachel feels she is fortunate to be accepted into such a prestigious program with the support of her friends and family nearby.

In her free time, Rachel enjoys traveling. Her favorite locations include the beach and the ski slopes. One day she strives to be successful enough to purchase a beach house so she can enjoy days filled with paddle boarding.