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Exploring the Correlation between Cognitive Awareness of Body Composition and Perceived Ventilatory Threshold

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Honors Research Project

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Introduction

Body composition has long been a focus of analysis in elite athletes. Most athletes look to lower their percentage of body fat while maintaining or increasing their levels of lean body mass. This, in theory, allows the athletes to perform at their most efficient level. Female collegiate soccer players are among these elite athletes. It can be a major advantage for an athlete to be have optimal lean body mass in order to compete at the most competitive levels. A soccer game lasting 90 minutes in total consists of constant interval-like training where athletes sprint, jog, walk and everything in between. It is clear that this is a very demanding sport that tests the limits of these athletes. The purpose of this investigation was to explore the relationship between body composition and the athlete's perception of these limits. Do athletes with higher body fat percentages perceive their ability as less than those with a lower body fat percentage? How much does perceived ability affect actual ability? Knowing the advantages of maintaining a healthy mental outlook paired with high fitness levels can help improve overall athletic performance. An athletes' awareness of their own limits can change the way they train. We can assess this awareness through looking at perceived and actual ventilatory thresholds, essentially changes in breathing and seeing if an athlete can pinpoint when this change of breathing occurs. This information could be valuable to the training habits of these young athletes. With this information in mind, we hypothesize that body composition will influence perceived ventilatory threshold.

Literature Review

Significance of the Anaerobic Threshold

Anaerobic threshold (AT) has long been used to gauge intensity of cardiovascular exercise. Initial research into the topic of AT was based on the idea that the acid-base balance in the body changes with exercise. Hill, Long, and Lupton (1924) were the first to describe that during low intensity exercise, ventilation and the respiratory quotient are low, and lactic acid (LA) does not accumulate in the body, versus during high intensity exercise where ventilation and the respiratory quotient are high and LA accumulates. Continued early research showed similar results in that LA accumulated in the body when the supply of oxygen in the muscles fell below demand (Margaria, Edwards, & Dill, 1933; Margaria & Edwards, 1934).

As technology and gas analysis techniques improved, exercise physiologists became able to examine new means of measuring AT. In the 1960s and 1970s, several studies were conducted that showed the dynamics of oxygen through a range of exercise intensities. Wasserman (1967) measured oxygen consumption (VO_2) and respiratory exchange ratio (RER) and found a positive relationship in the changes of these values and LA concentrations at different exercise intensities. These findings spurred more research into ventilatory changes at the AT.

Whipp and Wasserman (1972) found that above the AT, measured VO_2 underestimates the true amount required for exercise. They found that this supply of energy must come from anaerobic sources of glycolysis and high-energy phosphates. This could be detected through the use of gas analysis. Later, Wasserman et al. (1973) used similar methods and found that changes in minute ventilation (VE) could also be used reliably to detect this threshold. In the same study, Wasserman, et al. (1973) also investigated whether the duration of each stage in the incremental tests affected the rate of LA accumulation. They tested time periods of 1-min and 4-min for each stage, and they found that while there was a slight difference in total LA accumulation, the relative rate of change of LA accumulation remained constant. This suggests that rate of LA accumulation is based on intensity of exercise rather than duration.

Perception of Anaerobic Threshold and Intensity

After the relationship between the ventilatory and LA changes at AT were solidified, some researchers began to examine the subject's perception of intensity at and near these thresholds. Joakimsson (1989) looked at the reproducibility of ratings of perceived exertion (RPE) at ventilatory threshold (VT) of fifteen well trained middle-long distance runners. Using a modified treadmill VO_2max protocol, he first tested his subjects to find their VT. He then had them perform two submaximal tests, one with incremental stages up to the workload corresponding to VT, and one interval stages above and below the workload corresponding to VT. For each test, the subject's reported their RPE during each stage. Analysis of the results showed that middle and long-distance runners were able to reproduce RPE at VT for identical workloads in the two different protocols.

Lieberman (1994) tested recreationally trained males on whether they could perceive the abrupt changes in ventilation associated with their AT during a maximal cycle ergometry test. He found a high correlation between the perceived ventilatory threshold (PVT), actual ventilatory threshold (VT), and lactate threshold

(LT), and therefore showed that PVT can be a useful indicator of AT in recreationally trained males.

Mertens (1998) investigated this concept further when he tested young male subjects on whether there was a significant difference in the intensity chosen by participants at which they “could hear their breathing” versus “could readily hear their breathing”. He found no significant differences between the two phases and determined that subjects responded to both phrases at approximately their VT, indicating that this young male population could also perceive the breathing changes associated with their AT.

Ng (2004) attempted to see if children could perceive the changes in breathing associated with VT. For this study on their first visit, the participants ran a treadmill test and were asked to raise their hand at the moment their breathing became audible (Audible Breathing Threshold/ABT). After this moment, the test was stopped. On the second visit, participants performed the same treadmill protocol, but this time to maximal effort and with breath by breath analysis. After both tests, the intensity at ABT was compared to the true VT. Results showed that ABT was within 7% of VT, demonstrating that ABT could be used as a reliable gauge for intensity at VT for children.

The Talk Test has also been researched to gauge VT. A Talk Test consists of participants reading a script to test for breathlessness. If the participant can read the entire script without any gasps for breath, it is counted as a pass, whereas if they struggle or cannot read at all because of breathlessness, it is counted as a fail. Dehart-Beverly, Foster, Porcari, Fater, and Mikat (2000) tested recreational walkers and joggers (24.1 ± 6.1 years) to understand if the intensity at their VT aligned with the intensity at which they failed the Talk Test. The authors found that the subjects could pass the Talk Test at and before VT, but clearly failed at an intensity above the VT. Quin and Coons (2011) conducted a similar study with fifteen young adults (13 males and 2 females) using the Pledge of Allegiance for their Talk Test and a treadmill protocol. One difference was that they chose to also measure LT. They found that failure of the Talk Test was more closely related to LT than VT, and that the intensity point of failure of the Talk Test was generally higher than the intensity at VT. Rodriguez-Marroyo, Villa, Garcia-Lopez, and Foster (2013) had similar findings in their study with their sample of highly trained cyclists. Each of these studies showed some relationship between the loss of the ability to talk comfortably and the VT and LT.

Little research, however, has investigated the ability for athletes to self-select intensities for training that are at or above their anaerobic thresholds. In one study, Madengue et al. (2005) studied nine male university athletes' ability to self-select proper intensities during their warm-up. They found that most, but not all, of these athletes were able to select an intensity within 10% of their optimal warm-up intensity (~60-70% of VO_2peak), indicating that there may be some discrepancy in the ability of different athletes to monitor and self-select an appropriate intensity that is asked of them.

Haile (2010) studied recreationally active males. These participants were told to self-select an intensity for 20-minutes of cycling that was "high enough for a good workout, but not high that (they) would not prefer to exercise at that intensity daily or at least every other day" (p. 33). Most of the participants chose an intensity that was above 50% of their oxygen uptake reserve. This showed that this sample can select an exercise intensity within the range recommended in ACSM's Guidelines for Exercise Testing and Prescription (2018). Guidelines consist of moderate (e.g., 40%-60% heart rate reserve [HRR] of VO2R) to vigorous (e.g., 60%-90% HRR or VO2R) intensity aerobic exercise for most adults, and light (e.g., 30%-40% HRR or VO2R) to moderate intensity aerobic exercise can be beneficial in individuals who are deconditioned. These recommendations, however, are used with the general population, and the study was also just limited to males.

VO_2max Testing Specificity

Studies have also been conducted that look at the specificity of the VO_2max test protocol to the usual mode of exercise of the participants. In a review of studies looking at the physiological responses of runners versus cyclists, Millet, Vleck, and Bentley (2009) found that runners had a higher VO_2max when tested in a running protocol versus a cycling protocol. They concluded that athletes should be tested in a modality that is closest to the way that they train and compete.

Another area of interest for researchers is the effect of pain on perception of intensity during aerobic testing. Slapsinskaite, A., Razon, S., Serre, N. B., Hristovski, R., & Tenenbaum, G. (2015) investigated the perception and location of pain during running and cycling VO_2max protocols. They found different local pain dynamics for the two modes. For both, participants noted the number of pain locations gradually increased with increasing intensity. For cycling, this pain was greatest in the quadriceps and hamstrings, while it was greatest in the quadriceps and chest while running. This showed a difference in the way that pain is perceived and demonstrates that using a different exercise modality can greatly affect the way participants feel during a VO_2max test.

A recent pilot study by Clemente and Nikolodais (2016) investigated the training habits of amateur (~20 years) male and female soccer players during scheduled practice, and over a period of one month. They found that the female soccer players spent more time training in the two highest intensity zones than their male counterparts. The participants also spent more time in the lowest intensity zone, possibly from a need to recover from the other high intensity moments. Males on the other hand, spent the most time in the moderate-to-vigorous intensity zones with less drastic changes in their intensity. This discrepancy between the type of intensity experienced at training demonstrates that even though they are playing the same sport, males' and females' cardiovascular requirements are different.

Body Composition and Perception of Intensity

Body compositions, specifically the amount of fat free mass vs fat mass, are known to be important factors in determining health. Multiple methods of measuring body composition are considered sufficiently accurate to act as a reference. Several techniques are usually paired together to optimize the accuracy of the body mass prediction.

Indirect Methods

Anthropometric measurements are the most basic method of assessing body composition. It involves measurements of body mass, size, shape, etc. This method allows the researcher or clinician to obtain an adequate measurement of overall adiposity in the body. However, the relative power of anthropometric measures is altered when weight is gained or lost (Duren et al., 2009).

Among these techniques, body mass index (BMI), because of its simplicity and cost-effectiveness, is one of the most widely used. BMI is simply calculated as weight/height. BMI is categorized by underweight, normal, overweight and obese. However, body mass index can be controversial because it cannot distinguish between fat and lean masses (Wells, 2005).

Another method commonly used is waist circumference. Waist circumference provides a simple measurement of health risks associated with excess fat around the central portion of the body. Studies investigating the relation of waist circumference with measures of abdominal fatness obtained from magnetic resonance imaging (MRI) have shown correlations consistently in the range of 0.5 to 0.8, although the associations with total abdominal fat tend be higher than those with intra-abdominal fat (Wells, 2005).

Measurement of neck circumference has recently been shown to identify overweight and obesity. It has also been shown to have a good correlation with age, weight, waist to hip circumferences and BMI. Neck circumference has been known to be a good indicator of upper body fat levels. Neck circumference has also been shown to predict metabolic abnormalities past those of typical anthropometric measurements (Saka et al., 2014)

Criterion Methods

Hydrodensitometry, also known as underwater weighing, is a technique that estimates body composition by measuring body density using weight, body volume and residual lung volume. This method relies heavily among the participants performance. The participant is completely submerged underwater and is told to blow out as much air as possible. A weight belt then measures the weight of the participant. The theory behind this technique is that fat free mass will sink while fat mass will float. If done correctly, this method can be extremely accurate (Duren et al., 2009).

The air displacement plethysmography method for measuring body density is a slightly less invasive version of underwater weighing. Because underwater weighing requires one to be completely submerged, many prefer this less difficult, more tolerable method. Air displacement works under many similar assumptions to that of underwater weighing. Again, tissue density is being measured, but now by the volume of air displaced by the individual. A machine called the BODPOD (COSMED, Concord, California), is typically used in this air displacement measurement (Lee & Gallagher, 2008).

Relation of Body Composition

Buresh (2004) shows the relationship between measures of body size and composition and velocity of lactate threshold in a group of 21 male runners. The participants repeated hydrostatic weighing 6 different times for accuracy and then were put through a stress test protocol. Blood lactate levels were taken in increments during the stress test. This study found that velocity of lactate threshold was significantly inversely related with body mass in a group of male runners. Nearly 58% of variability in velocity of lactate threshold was explained by body mass. However, the results suggest that all body mass regardless of fat tissue or lean tissue influenced the production of lactate (Buresh, Berg, & Noble, 2004).

Maciejczyk (2015) investigated the physiological responses in 33 inexperienced male runners with similar body masses but different body composition. Anthropometric measurements were taken before beginning two different stress tests: graded incline test and a submaximal running test. No significant difference was found in those that had higher body fat percentages. Therefore, body mass regardless of fat percentage or lean body mass does not have a significant effect on physiological response.

Differences in Intensity

Individuals differ in the intensity of exercise that they prefer and the intensity that they can tolerate. The Preference for and Tolerance of the Intensity of Exercise Questionnaire (PRETIE-Q) is used to explore these different preferences of exercise. It is used to examine the psychometric properties for preference and tolerance of exercise. Ekkekakis (2008) performed a study on 601 college women and found that both preference and tolerance were related to frequency of participation. It was found to be an adequate tool to analyze the cognitive inclinations to exercising.

Methods

Subjects

Seventeen participants were recruited from The University of Akron (UA) Women's Soccer team. Each player was cleared for running by the certified athletic trainer. The participants were asked to refrain from strenuous activity or alcohol for 12 hours, and caffeine or food for 2 hours prior to maximal testing.

Procedures

All testing was conducted in the Exercise Physiology Lab at UA. Upon arrival, participants were informed of the testing procedures and completed an informed consent form (Appendix A). Next, all resting measurements were taken. These measurements included height, weight, waist circumference, and neck circumference. Body composition was then estimated by using the BodPod (COSMED, Concord, California). Subjects were fitted with a Polar heart rate monitor (Polar Electro Oy, Kempele, Finland) (Giles, D., Draper, N., & Neil, W. 2015) and a mask for the VO_2 max test was appropriately fitted and assembled for each participant. Each participant were then read a script (Appendix B) to explain to them what a VT is, and were told to raise their hand during the maximal testing when they believed they had reached their VT.

VO_2max Testing

Subjects were warmed up on the treadmill for 3 minutes at 3.5mph and 0% grade. After the warm up, the treadmill increased to 5.0 mph and 0% grade. The speed then increased each minute by 0.5 mph. This protocol was based on similar protocol from Joakimsson (1989). Speed continued to be increased in this manner until 9.5 mph. If a participant was still running at this point, the speed remained constant at 9.5 mph, and the grade was then increased by 2% each minute. The full protocol is listed in Figure 1. This protocol with minimal change in grade was chosen in order to mimic the running involved in soccer, but to limit the amount of time that participants spent completing the test.

Subjects were actively encouraged to give a maximal effort. The test was terminated at volitional fatigue, unless either of the following conditions occurred: 1) if the subject showed signs of abnormal stress such as impaired coordination, pallor, or dizziness, 2) if there is equipment failure. Upon termination of the test, the subject straddled the belt, the treadmill was slowed to 3.0 mph, and the grade reduced to 0%. At this time, the subject's finger was pricked once more to measure lactate levels using the Nova Biomedical Lactate Plus in mmol/litre (Nova Biomedical, Waltham, Massachusetts). Subjects then completed a cool-down by walking at 3.0 mph and 0% grade for 5 minutes.

After the completion of the maximal testing and cool-down, the participants were asked to fill out the Preference for and Tolerance of Intensity of Exercise Questionnaire (PRETIE-Q) (2015) to garner more personal information about their exercise preferences (Appendix C). Statistical analysis was performed using Pearson correlation and related *r* and *p*-values.

Statistical Analysis

All statistical analyses were done using Microsoft Excel (Microsoft, Redmond, Washington). A correlation was computed to find the value of the Pearson correlation coefficient (*r* value). This allowed the researcher to describe how two variables were related. These tests were completed on perceived and actual ventilatory threshold, lean and total body mass, neck circumference and body fat composition, waist circumference and body fat composition, body fat composition and perceived ventilatory threshold, and the preference for high or low intensity exercises.

Significance was set at $p < 0.05$. Results were taken to be correlated if the R-squared value was greater or equal to >0.85.

Results

This study analyzed the correlation between body composition and perceived ventilatory threshold. When looking at results, several different measurements of body composition were accounted for, results from VO_2max testing and a PRETIE-Q questionnaire to tie all of the data together. We wanted to see if there was any type of correlation between body composition measurements and perceived ventilatory threshold. We also wanted to see if preferences for exercise intensity (PRETIE-Q) had any correlation with these results. Correlations between this data could tie in to the overall idea that an athlete being more aware of their own training tendencies and limits can improve their training habits and therefore improve their overall performance.

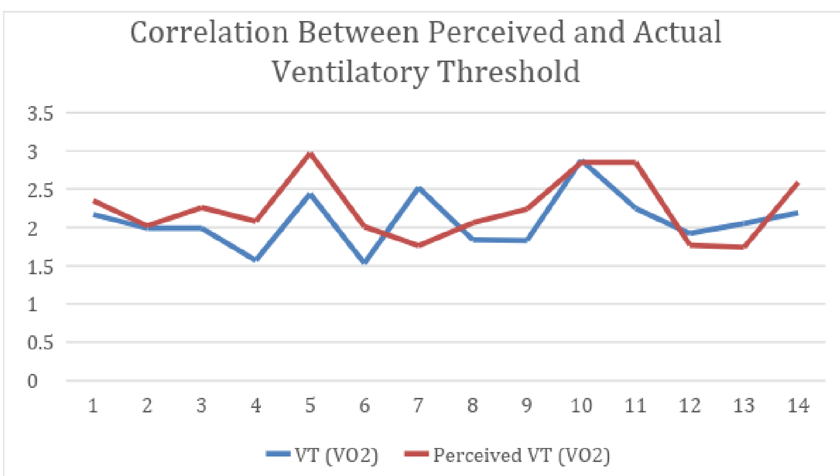

Figure 1: Analyses the correlation between Perceived and Actual Ventilatory Threshold (0.5289).

Figure 1 describes the correlation between perceived and actual ventilatory threshold, as shown is 0.5289 (r=0.0600, p =0.0518), which is a fairly moderate positive correlation. This shows that the two data sets may share some commonalities. As shown in the chart above, one can clearly see the close nature in the perceived threshold versus the actual threshold. Many of the subjects were able to accurately sense their threshold or come extremely close. This is particularly interesting because soccer players are not trained to know when this action occurs. Even so, according to these findings, the participants were more accurate than anticipated.

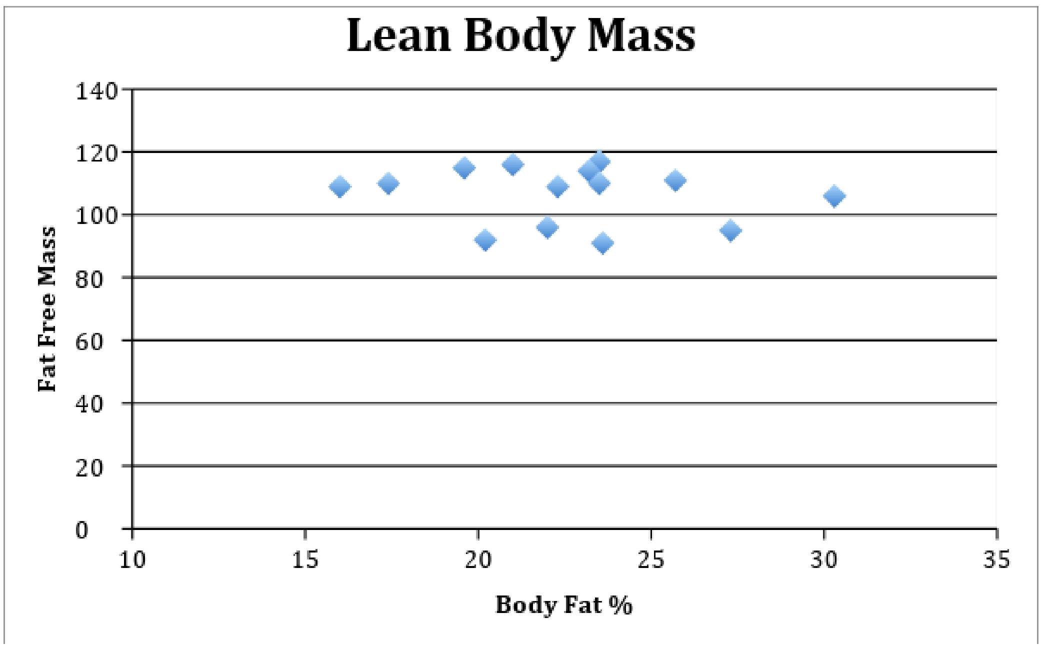

Figure 2: Body fat percentages compared to fat free mass of the seventeen participants. The mean body fat percentage was 22.54% with a standard deviation of 3.61%.

Body composition testing revealed that seventeen subjects had an average age of 19(±1.55) years. The activity levels for these individuals were extremely active considering it is known that the participants are Division I athletes who are in season. This takes into consideration that the participants are practicing daily, even sometimes twice a day. For this group, the mean body fat percentage of the subjects was 22.54% (+/-3.61%). Subsequently, according ACSM's Guidelines for Exercise Testing and Prescription (2018), almost all of the athletes fell in the "Average", category, which is 21-32% body fat (American College of Sports Medicine, 2018).

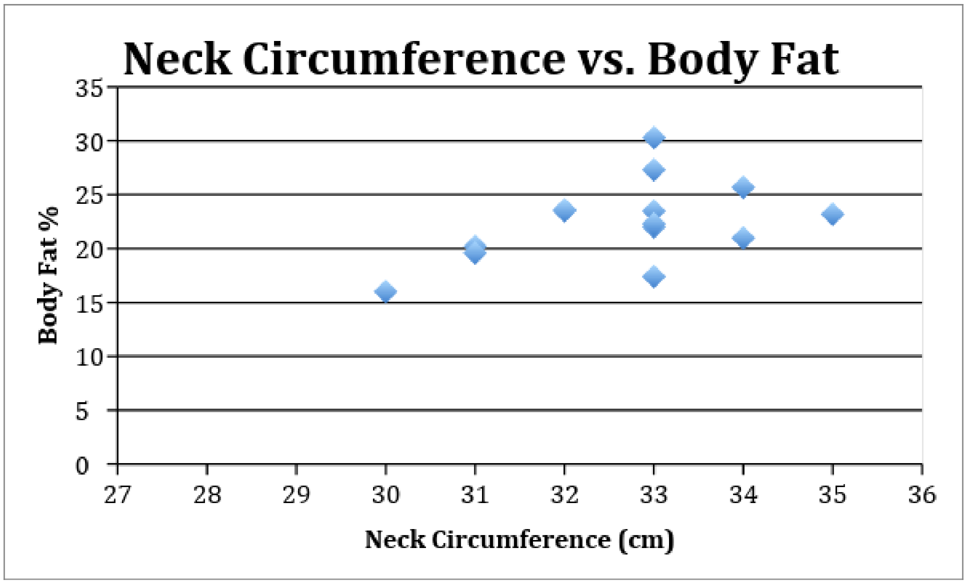

Figure 3: Neck circumferences in (cm) compared to body fat percentages. The average neck circumference was 32.64 cm with a standard deviation of 1.29 cm.

Neck circumferences has been looked at to consider if it is a useful measurement of body composition. It can be a marker of upper body subcutaneous adipose tissue distribution. Based on previous research from Hingorjo, M. R., Quresh, M. A., & Mehdi, A. (2012), a cut off for women of a circumference less than or equal to 32 cm has been made for overweight/obesity. However, for this study 32 cm was the average. Neck circumference has been shown to be a useful measure in the general population but here, may not be the best measure of body composition. As shown in Figure 3, neck circumferences are not necessarily indicative of a higher body fat percentage in this population of athletes. Statistically, the correlation between the two was +0.478 (*r*=0.0643, *p* =0.084), which is also a fairly moderate positive correlation making the two data sets not particularly relevant towards each other.

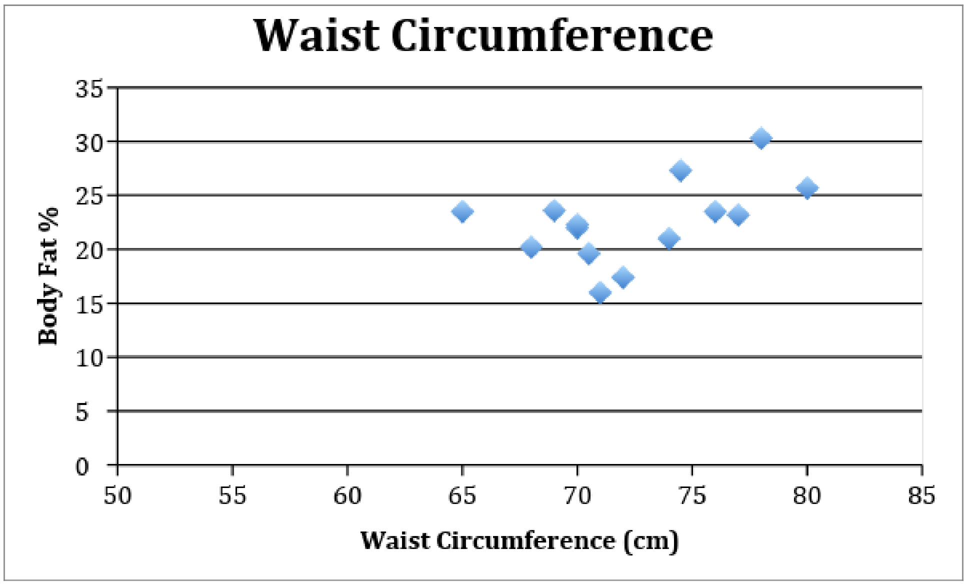

Figure 4: Waist circumferences vs. body fat percentages for the seventeen participants. The average waist circumference was 72.5 cm with a standard deviation of 4.1 cm.

Based on previous research waist circumferences greater than 85.5 cm have been shown to be associated with health problems such as heart disease, type 2 diabetes, obesity, and high blood pressure (Hassan, M., Ahmad, N., Adam, S. M., Nawi, A., & Ghazi, H. 2016). As shown in Figure 4, none of the participants had a waist circumference greater than 85.5 cm. However, similarly to neck circumference, waist circumference in this study was not necessarily indicative of body fat percentages. Statistically speaking, the correlation between the two was +0.484

(r=0.0638, p =0.0795), which again is a fairly weak positive correlation showing that the two data sets are not particularly relevant.

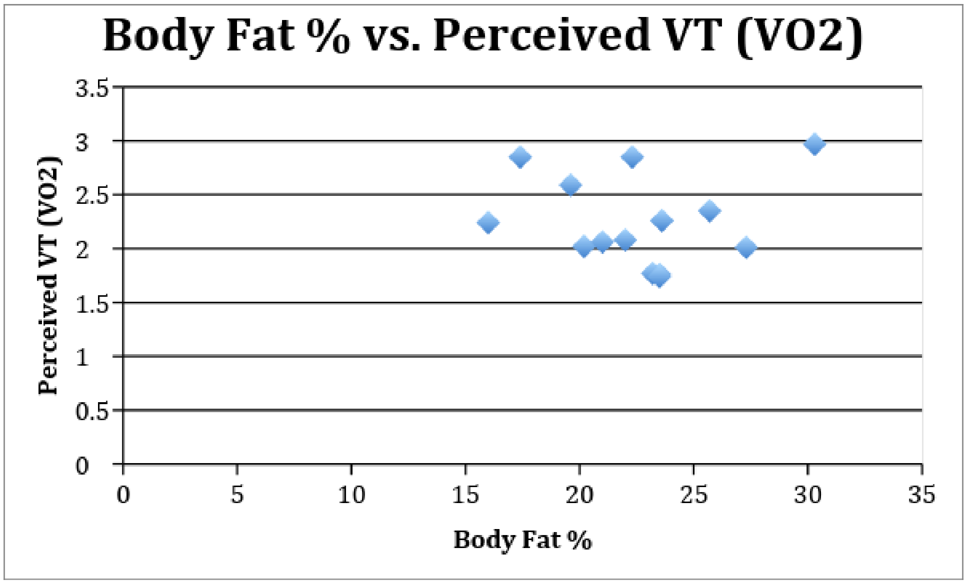

Figure 5: Correlation between body fat percentages and perceived ventilatory threshold.

Body fat percentage that was estimated by using the Bod Pod and perceived VT was taken from performing a VO_2max test and participants raising their hand when they thought they had a change in breathing. The results from this small population showed the correlation between body fat percentages and perceived ventilatory threshold in Figure 5. The correlation is 0.012 (r=0.0833, p=0.966), which is a weak relationship and not statistically significant.

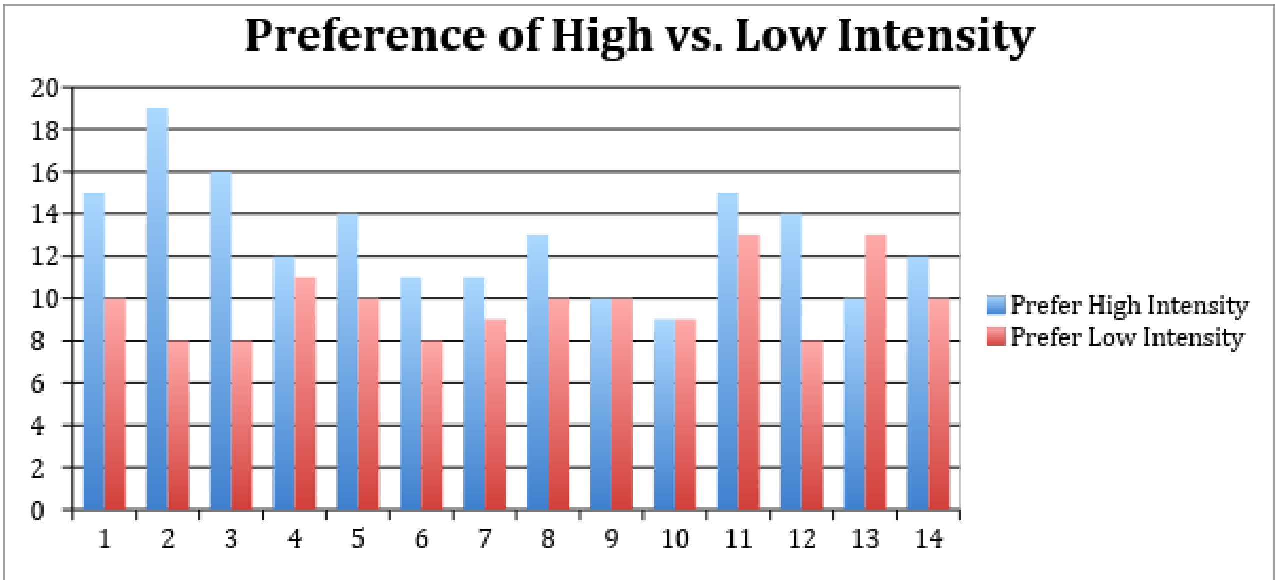

Figure 6: PRETIE-Q questionnaire summations of results of preferences of high vs. low intensity exercise.

The PRETIE-Q questionnaire is comprised of 16 questions that each relate to preference for high intensity (6,10,14,16), preference for low intensity (2,4,8,12), having a high tolerance for high intensity exercise (5,7,11,15) or having a low tolerance for high intensity exercise (1,3,9,13) (Ekkekakis, P., Hall, E. E., & Petruzzello, S. J., 2005). Each question was to be answered on a Likert scale of 1-5 stating that, 1=I totally disagree to the other end of the spectrum to 5= I totally agree. Based on the answers to each of these sets of questions, a summation of those numbers were taken to not only show if they prefer one type of exercise or the other type of exercise but the degree at which they prefer the type of exercise. Figure 6 indicates that almost every participant in this study preferred higher intensity exercise to lower intensity exercise. A definite variation can be seen between one participant to the next. In this study, many of the participants seemed to enjoy both levels of intensity to some extent. Statistically, there was a low negative correlation of -0.237 (r=0.0787, p =0.415).

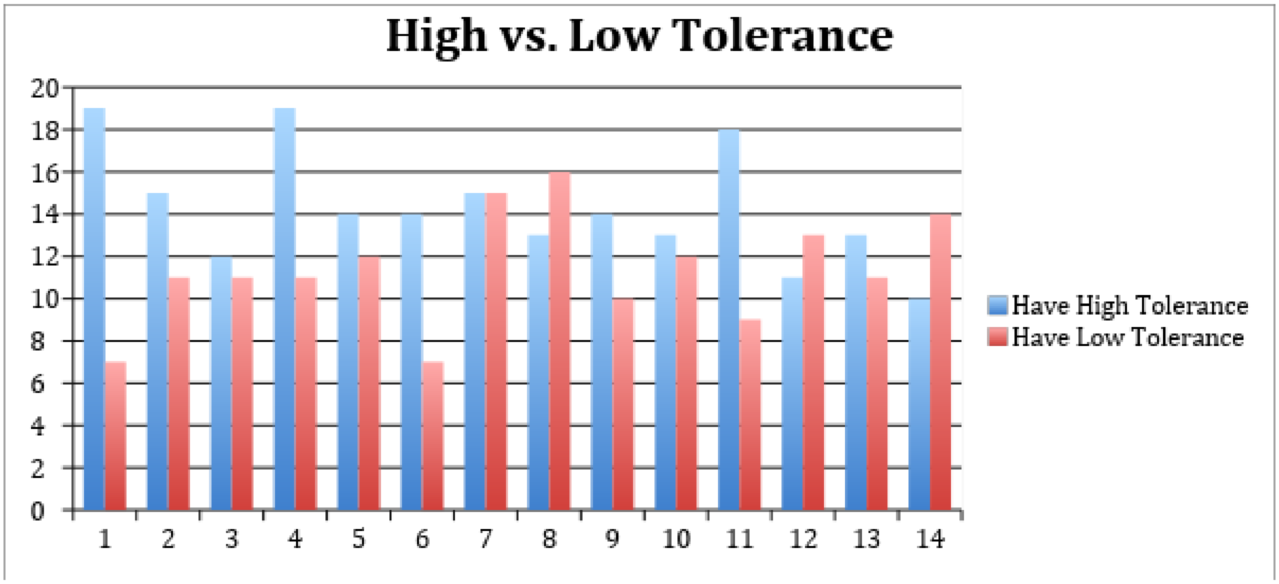

Figure 7: PRETIE-Q questionnaire results of participants having a high vs. low tolerance for high intensity exercise.

Figure 7 shows a similar set of data to Figure 6; however, this figure depicts the participants tolerance levels. Most participants believed they had a high tolerance rather than low tolerance for high intensity exercise, but the margin was still close. Statistically, there was a moderate negative correlation of -0.521 (r=0.0608, p =0.0564).

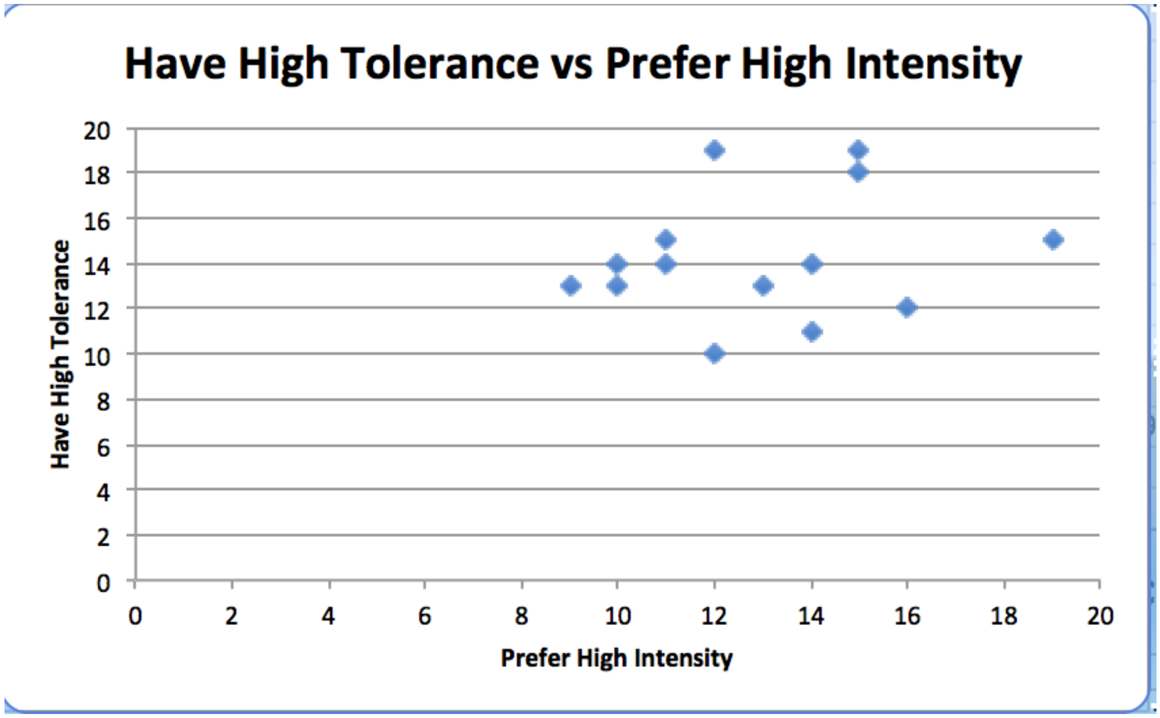

Figure 8: PRETIE-Q questionnaire results of the correlation between having high tolerance for intense exercise and preferring high intensity exercise.

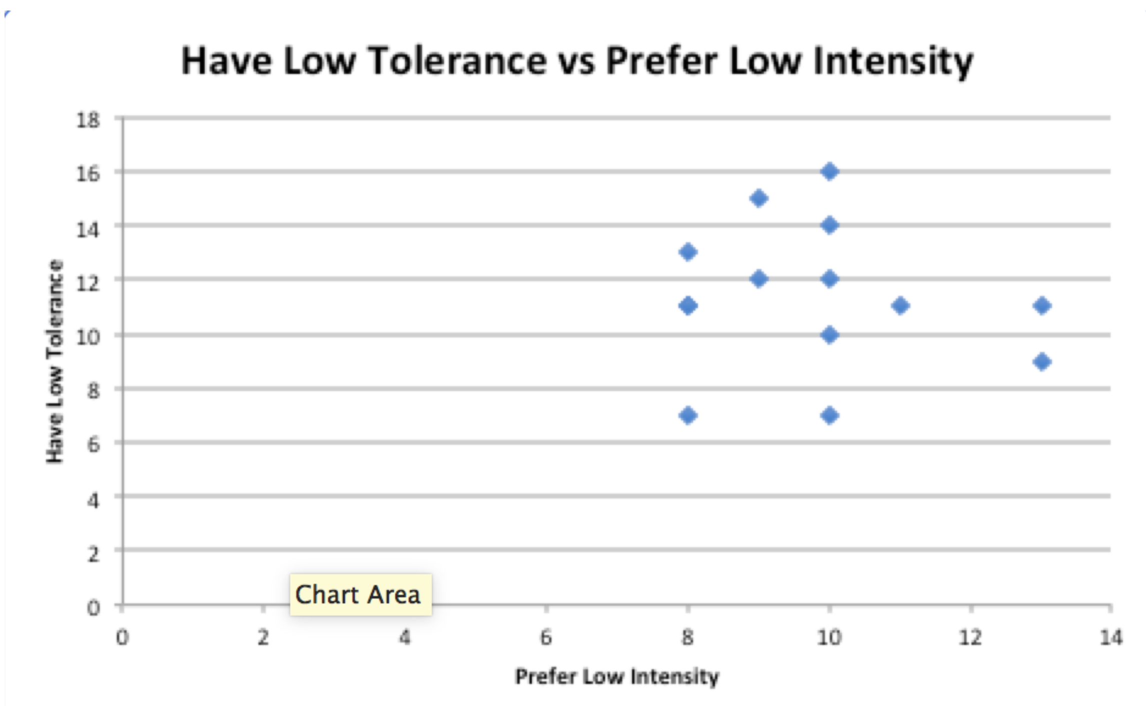

Figure 9: PRETIE-Q questionnaire results of the correlation between having low tolerance for intense exercise and preferring low intensity exercise.

There was a low negative correlation between preference of low intensity and having low tolerance (-0.103) (r=0.0825, p =0.726) and a low positive correlation between preference of high intensity and having high tolerance (0.195) (r=0.0801, p =0.504) as shown in Figure 8 and Figure 9. Therefore, we can assume that there is no relationship between preferences of intensity and tolerance of high intensity.

Discussion

In this study, participants perceived ventilatory threshold was much closer than expected to actual ventilatory threshold. Because these athletes had never been trained to recognize when this point occurred, the resulting closeness of the data was surprising.

When perceived ventilatory threshold was compared to body fat percentages, there was almost no correlation. We can assume that body fat percentage does not affect an athlete's perceived ventilatory threshold. We can assume that body composition does not affect an athlete's cognitive awareness of their own body and the changes it makes when exercising.

The anthropometric measurements taken in this study were shown to have little correlation to body fat percentage. Therefore, we can assume that with the athletic nature of the participants in this study, neck and waist circumference measurements were not the most effective measurement of body composition. If this study were done on the general public, it may have been more indicative of overall body composition. Because we are looking at athletes, we must account for muscle distribution and how that may skew this data set as well. Many athletes, specifically soccer players, exercise the muscles around their neck to help prevent concussions. This could be one reason the neck circumferences were typically higher than the cut off mark for women. The athletes in this study fell in the categories of "Good" with 17.1-20.5% body fat and "Average", which is 20.6-23.6% body fat. According to ACSM's health-related physical fitness assessment manual (2013), an average female falls around 25% body fat. Most participants in this study fell into categories under the body fat percentage for an average female. This was not surprising considering these are Division One athletes who perform at a high level every day.

Looking at the PRETIE-Q questionnaire results, which measured one's preference and tolerance for intensity of exercise, there was also extremely low correlation to perceived VT. It would be interesting in future research to take this a step further and participate in personality tests to show which participants react to stimulus better. Typically, people with higher tolerance have a low reaction to stimulus whereas people who have low tolerance typically are more sensitive to stimuli (Haile, 2010).

A similar study should be done but with a population of college age non-athletic females where hopefully we could see additional similarities with the data sets. Here we would most likely see a wider range of body fat percentages and aerobic capacities, which would alter the results of this study greatly. Regardless of whether female college athletes prefer high intensity exercise or not, it is absolutely something to which they are accustomed. Taking more of a general population would make this data more usable in the scope of this study.

Similarly, using a test that differs from a VO_2max test could help look at high intensity exercise in a better fashion. In a previous study Millet, Vleck, and Bentley (2009) concluded that athletes should be tested in a modality that is closest to the way that they train and compete. Perhaps a Bleep test would be more closely related to the way soccer players train and compete than a VO_2max test. A Bleep test utilizes an agility aspect and starting and stopping in a game-like fashion whereas a VO_2max test does not (Paradisis, G. P., Zacharogiannis, E., Mandila, D., Smirtiotou, A., Argeitaki, P., & Cooke, C. B., 2014).

Another test that could be done is a repeat Wingate paired with a perceived pain scale. A Wingate test is a cycle test of anaerobic leg power conducted over 30 seconds (Bar-Or, 1987). It is typically used to measure an individual's anaerobic capacity and anaerobic power outputs. This could more closely measure high intensity and tolerance for high intensity exercise as compared to the aerobic nature of a VO_2max test. The use of the PRETIE-Q questionnaire and these different modalities of exercise could change the course of these data sets and perhaps a correlation would become clearer.

Subsequently, further and more extensive research needs to be done to obtain more knowledge on the relationship between body composition and perceived VT.

Conclusion

The purpose of this study was to examine the correlation between body composition and perceived ventilatory threshold in female collegiate soccer players. The results showed close to no statistically significant correlation between the two sets of data. There was also an extremely low statistical correlation between body composition and actual ventilatory threshold. Therefore, we cannot say that body composition regardless of lean mass or fat mass has a physiological effect on ventilatory thresholds. Subsequently, this data disproves our hypothesis that body composition effects perceived ventilatory threshold. When looking at an athletic population, we can conclude that neck and waist circumferences are not the best measurements for body composition. We can also conclude that these athletes had a higher awareness of perceived VT than expected. When looking at the PRETIE-Q questionnaire, we found some interesting data showing the degrees of intensity and levels of tolerance for each participant. This data is important to look at because a determined mentality, is a component of self-determination. Self-determination is an important concept in motivation and success (Deci and Ryan, 2008) as well as an awareness of one's limits are important tools for an athlete to possess. Looking at not just one aspect, such as body composition, but all aspects can help have a greater understanding of each athletes' specific needs. Knowing this, we can make great strides in improving training and performance.

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APPENDIX A

INFORMED CONSENT

The University of Akron
Institutional Review Board

Title of Study: The Accuracy of Female Collegiate Soccer Players in Self-Detecting Anaerobic Threshold

Introduction: You are invited to participate in a research study being conducted by Nicole Krueger, a graduate student in the School of Sport Science and Wellness Education at the University of Akron.

Purpose: Success in women's collegiate soccer cannot be possible without high cardiorespiratory fitness. Often times in order to keep up with the demands of the game and maintain fitness standards, student athletes need to train outside of their scheduled practice times. Coaches and strength and conditioning specialists can attempt to help their athletes by prescribing training workouts for them to do on their own. The difficulty in this resides in the ability of the athletes to train at an effort level required to increase their fitness. Unlike runners or cyclists, soccer players are not often taught how to do this and to properly train their aerobic (lower intensity) and anaerobic (higher intensity) systems. Therefore, they may lack knowledge that is essential to their success in their sport.

Improvement in soccer-specific cardiorespiratory fitness will not happen if the intensity of training does not reach a certain level. This level is called your anaerobic threshold, and it indicates a change in you breathing and the build-up of lactic acid in the body. Studies have shown that when you train above this threshold, you can make improvements in both your aerobic and anaerobic energy systems. Therefore, the purpose of this study is to determine if female collegiate soccer players could self-detect changes in ventilation associated with their ventilatory and lactate thresholds.

Procedures: Once you have been cleared by The University of Akron athletic training staff for running, and you have reviewed and signed this informed consent form, you will be approved to participate in this study. You have been asked to refrain from strenuous activity or alcohol for 12 hours, and caffeine or food for 2 hours prior to this testing. All testing will be conducted in this exercise physiology lab at the university.

After approval, all resting measurements will be made. Height, weight, waist circumference, and neck circumference will be measured. Body composition will then be tested using the BodPod. You will then be read a script explaining what your ventilatory threshold is, and when to raise your hand during testing.

After this, will begin taking the resting measures for the maximal exercise testing. Resting heart rate and blood pressure will be taken, and lactate levels will be measured by finger prick. You will then be fitted with a Polar heart rate monitor and a mask connected to a gas analyzer. You will warm up on the treadmill for 3 minutes at 3.5mph and 0% grade. After the warm up, you will start the maximal testing consisting of modified treadmill protocol. The treadmill will start at 5.0 mph and 0% grade. The speed will then increase each minute by 0.5 mph. Speed will continue to be increased in this manner until 11.0 mph. If you are still running at this point, the speed will stay at 11.0 mph, and the grade will then be increased by 2% each minute. This protocol with minimal change in grade was chosen in order to mimic the running involved in soccer as much as possible.

You will be actively encouraged to give a maximal effort. The test will be terminated at volitional fatigue, unless either of the following conditions occur: 1) if the subject shows signs of abnormal stress such as impaired coordination, pallor, or dizziness, 2) if there is equipment failure.

Upon termination of the test, you will straddle the belt, the treadmill will be slowed to 3.0 mph, and if applicable, the grade will be reduced to 0%. At this time, your finger will be pricked once more to measure lactate levels. You will then cool-down by walking at 3.0 mph and 0% grade for 5 minutes.

Risks and Discomforts: Because this research study is based on maximal effort testing, you will be asked to give your best effort. You may experience muscle aches and breathing discomfort as you fatigue. You may also experience discomfort during the collection of lactate levels via finger prick. All testing will be conducted by trained exercise professionals.

Benefits: The benefits of you participating in this study include experiencing a breathing-analyzed maximal exercise test, and learning your maximal oxygen consumption and body composition.

Payments to Participants: None.

Right to refuse or withdraw: Taking part in this project is entirely up to you, and no one will hold it against you if you decide not to do it. If you do take part, you may stop at any time.

Anonymous and Confidential Data Collection: Any identifying information collected will be kept in a secure location and only the researchers will have access to the data. Participants will not be individually identified in any publication or presentation of the research results. Only aggregate data will be used. Your signed consent form will be kept separate from your data, and nobody will be able to link your results or responses to you.

Confidentiality of records: Will be maintained.

Who to contact with questions: Advisor, Ronald Otterstetter: 330-972-7738, Principal Investigator, Nicole Krueger: 602-373-3249

This project has been reviewed and approved by The University of Akron Institutional Review Board. If you have any questions about your rights as a research participant, you may call the IRB at (330) 972-7666.

Acceptance & signature: I have read the information provided above and all of my questions have been answered. I voluntarily agree to participate in this study. I will receive a copy of this consent form for my information.

______________________________ ________________

Participant Signature **Date**

APPENDIX B

SCRIPT

To be read to all participants before VO_2max testing:

"Today you will be running a maximal exercise test. The entirety of the test will take place on the treadmill. After a warm up, you will start at 5.0mph and 0% grade. Each minute, the speed will increase 0.5mph until you reach 9.5mph. If you are still running at that point, the grade will begin to increase by 2%. We want you to give this test your best effort.

With the increasing speed, your body will transition from using its aerobic system to more of its anaerobic system to keep up with the energy demand. When this happens, your breathing changes. This will happen at some point during this test. Therefore, we would like you to raise your hand when you notice a change in your breathing, such as when you can hear or readily hear your breathing."

APPENDIX C

Preference for and Tolerance of the Intensity of Exercise Questionnaire

Inventory of Exercise Habits

Please, read each of the following statements and then use the response scale below to indicate whether you agree or disagree with it. There are no right or wrong answers. Work quickly and mark the answer that best describes what you believe and how you feel. Make sure that you respond to all the questions.

1 = I totally disagree *2 = I disagree* *3 = I neither agree nor disagree* *4 = I agree* *5 = I totally agree*

1.	Feeling tired during exercise is my signal to slow down or stop.	1	2	3	4	5
2.	I would rather work out at low intensity levels for a long duration than at high-intensity levels for a short duration.	1	2	3	4	5
3.	During exercise, if my muscles begin to burn excessively or if I find myself breathing very hard, it is time for me to ease off.	1	2	3	4	5
4.	I'd rather go slow during my workout, even if that means taking	1	2	3	4	5
5.	While exercising, I try to keep going even after I feel exhausted.	1	2	3	4	5
6.	I would rather have a short, intense workout than a long, low-int	1	2	3	4	5
7.	I block out the feeling of fatigue when exercising.	1	2	3	4	5
8.	When I exercise, I usually prefer a slow, steady pace.	1	2	3	4	5
9.	I'd rather slow down or stop when a workout starts to get too tough.	1	2	3	4	5
10.	Exercising at a low intensity does not appeal to me at all.	1	2	3	4	5
11.	Fatigue is the last thing that affects when I stop a workout; I have a goal and stop only when I reach it.	1	2	3	4	5
12.	While exercising, I prefer activities that are slow-paced and do not require much exertion.	1	2	3	4	5
13.	When my muscles start burning during exercise, I usually ease off some.	1	2	3	4	5
14.	The faster and harder the workout, the more pleasant I feel.	1	2	3	4	5
15.	I always push through muscle soreness and fatigue when working out.	1	2	3	4	5
16.	Low-intensity exercise is boring.	1	2	3	4	5

PRETIE-Q

Retrieved from: Ekkekakis, P., Hall, E. E., & Petruzzello, S. J. (2005). Some like It Vigorous: Measuring Individual Differences in the Preference for and Tolerance of Exercise Intensity. *Journal of Sport and Exercise Psychology,27*(3), 350-374.