Determining the Anaerobic Power Output Differences between the Genders in Untrained Adults

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Abstract

Introduction

Anaerobic power is power used in high-intensity bouts of exercise lasting fewer than ten seconds; which is the peak amount of time for phosphocreatine reserves to empty as a primary fuel source. It is expressed in terms of watts of force per kilogram of bodyweight. Power is considered a crucial component in overall athleticism. Ample power tends to be a key difference maker in short-terms bouts of fast twitch, Type I myo-fiber, events. For example, athletic events, or competitions which call for optimal power output, are weight lifting, sprinting, jumping and wrestling, although may other team sports and individual sports and competitions also have high anaerobic power output demands. Anaerobic power can be measured and improved. The three physical assessments in this study are commonly used to measure power. Each has been researched and normative and standards have been established for force production by their use. They are the Vertec vertical jump, Force plate and Wingate tests (WAnT). Also, several formulas are used to calculate power output from the vertical displacement from the Vertec. These formulas are named for the scientists who developed them. They are the Lewis, Sayer, Harman and Johnson formulas. In the same way there exists a most accurate way to measure someone's running speed, certain power output measuring tests have proven to be superior to the others. The force Plate is currently the "gold standard" for measuring anaerobic power output. Because having a higher threshold for anaerobic power output is a clear advantage to most sports and skills it is important to determine power output to know if a competitive disadvantage exists. Most people might assume because males are generally physically stronger and carry more muscle than females per kilogram of bodyweight, males must produce more power. But because we understand anaerobic power is a ratio of watts of force to kilograms of bodyweight, this assumption may not be the actual case. It is expected for there to be no significant difference of anaerobic power output between the male and female subjects based on power/mass ratios in the three anaerobic power output assessments.

Purpose

The purpose of this study was to determine if a difference of anaerobic power output between the genders existed while determining the most reliable power-measuring exams and formulas.

Methods

Ten non-athlete males (age 27.1 yrs., height 181.67 cm, weight 89.82 kg) and eight non-athlete women (age 24.13 yrs., height 167.95 cm, weight 74.97 kg) of the University of Texas at Arlington volunteered to participate in this study. Each subject contributed data in the three anaerobic power output assessments. Subjects were randomly divided and assigned to a particular starting exercise assessment at random order. Each subject preformed a power output test using Force Plate technology, which displays the power measurements on-screen without the need for hand-written calculations. In the force plate test, subjects stood still on the measurement pad so weight could be recorded and calibration accomplished. Then, the subject jumped as vertically high as they could from the plate and landing back on the plate; then the power output was calculated. Subjects also performed a vertical jump test with equipment designed by Vertec. In this test subjects measure their standing reach in inches, then subtract that amount from three trails of a standing maximal vertical jump. The results of the Vertec were used in each formula designed to measure anaerobic power. For the results of the Vertec subjects performed their own power calculations using said formulas. The formulas are the Lewis, Sayer, Harman and Johnson formulas. Subjects also performed a Wingate Test, which also displays the anaerobic power output as well as fatigue rate.

While fatigue rate is not a direct reflection of anaerobic power production, it does provide limited insight to the storage reserves of phosphocreatine the subject posses. During the Wingate test subjects peddle as fast as they can for one full minute after a warm-up of pedaling at 80 rotations per minute for one minute. At the conclusion of each test subjects were given ample time to recover before beginning the next test.

Results

The anaerobic power output difference between the genders was significant based on the results of most tests but not every test. The null hypothesis stated that there would be no difference in anaerobic power output between the genders. In the Force Plate test the distribution of the countermovement among males to females (A: 42.3, 24.88 ±: 9.05, 7.64) rejects the null hypothesis (p = 0.003). The distribution of Peak Power among males to females (A: 5365.3, 3123.85±1088.459, 884.685) rejects the null (P= 0.001). The distribution of Peak Power/W/kg among males to females (A: 58.31, 39.70 ± 9.353, 12.249) rejects the null hypothesis (P=0.009).Within the findings from the Vertec vertical jump test we find only significant differences. We reject the null hypothesis across the board in the displacement category (P= 0.006), Lewis Power (P= 0.011), Sayer Power (P= 0.002), Harman Peak and average power respectively (P= 0.001, 0.000), and Johnson Peak power and average power respectively (P= 0.002, 0.027).Our Wingate test findings rejected the null hypothesis in the categories of average power (P= 0.000), peak power (P= 0.000), average power/kg (P= 0.000), peak power/kg (P=V0.027).

Conclusion

Significant power output differences do exist in the tested sample population. This conclusion was based on the results of Wingate testing and comparative means in the Force Plate test. It was found that there were significant gender differences in peak power and mean power revealing that other factors in addition to body dimensions account for the gender differences in anaerobic power. The results of the study indicate that the relationships of their findings showed that when individuals with different body sizes are compared, individuals with small body size are at a disadvantage when compared with absolute anaerobic power parameters, on the other hand, large body sized individuals are at a disadvantage when compared with respect to ratio scaled parameters. Therefore, analysis should be considered as a method to account for the influence of body size in intergroup and gender comparisons of anaerobic performance (Hazir & Kosar, 2007). This is not out of line with what we predicted in our introduction. Other studies used in research suggest a similar result. In terms of the highly affective Wingate test, when using the lighter resistance (0.080 kg/kgbw), power production for males was greater than almost all previously reported findings by approximately 10 to 30%. When using the heavier resistance (0.095 kg/kgbw), the increase in power production in males was even greater (Richmond et al., 2011). This result suggests that no method adequately adjusts for the gender differences and thus the best methods for studying physical performance of males and females would be separately (Hazir & Kosar, 2007).

Background

Anaerobic power is power used in high-intensity exercise activities lasting fewer than ten seconds. There is a difference in anaerobic muscular power and muscular endurance. This differentiates the skills required to excel in a sport like football, where action bouts require maximal physical exertion for brief moments followed by short rest periods, rather than soccer, where the majority of the competition requires moderate levels of exertion for a longer period of time from its participants. Power is expressed in terms of watts of force per kilogram of bodyweight. As stated before, power is considered a crucial component of overall athleticism. Ample power tends to be a key difference maker in short terms bouts of fast twitch events. For example: weight lifting, sprinting, jumping and wrestling. Anaerobic power can be measured by way of several assessments developed over the years from research-based exercise physiologist and sports trainers. Anaerobic power can be improved through exercise and training specified to increase power output. When considering an athlete’s performance in a power output measuring exercise, it is important to consider the other factors working in the athletes favor simultaneously. Aerobic fitness of high-performance explains about 40% of the variance in performance of power output results. This suggests that other factors than anaerobic power such as technical abilities need to be considered in the physiological assessment of these athletes, even in anaerobic power assessments such as the Wingate Test or Force Plate (Vaitkevičiūtė & Milašius, 2012). Because having a higher threshold for anaerobic power is a clear advantage to most sports and skills it is important to determine power output.

With the introduction of Title 9 there has been increased involvement of female participants in high-intensity exercise and sport. As a result, more questions are being asked about the athletic capabilities and physical strength output female sport participants possess. From there, some findings have sparked important research questions about male and female differences in exercise performance (Clare & Webber, 2006). These questions about gender differences are relevant due to the establishment of training protocols and exercise prescription, and in the field of sport-related physical therapy treatment female participants may receive. Much past research has typically sought to answer questions based on muscular production differences and determine physiological differences based on anatomy and biomechanical factors among the genders. Most people might assume because males are generally physically stronger than females, males must produce more power. This study is laid out to determine if gender difference do exist, solely in terms of anaerobic power output. It is also a goal of this study to determine the most reliable power-measuring exercise tests and power measuring formulas. Of the three power assessments used in this research the Wingate is among the most studied. In a previous study, which also used the Wingate, it was found the difference between the sexes in peak leg power was as high as 33% (Van Praagh, 1990). But because we understand anaerobic power is a ratio of watts of force to kilograms of bodyweight this may not be the case once all other factors are considered.

When refereing to Figure 1 the size difference in the subjects used in this study is clearly apparent. In maximal anaerobic tests, like the WAnT, ratio scaling for lean body mass creates a disadvantage for individuals who have large body size compared to small body sized individuals, as during these types of activities only limited muscle mass is active. The above-mentioned problems have also been experienced in gender comparisons (Hazir&Kosar, 2007). It is expected for there to be no significant difference of anaerobic power output between the male and female subjects. However, ample data show that male participants generate significantly greater lower limb muscle power than female participants (Clare & Webber, 2006). This data is contradictory to previous findings. Previous studies have sought out to find the results to the same question. Findings are controversial when data are expressed relative to body weight, lean body mass, muscle cross sectional area or active muscle mass. Some studies reported that gender differences in anaerobic performance were eliminated after normalization of thedata for anthropometric measures while others did not (Hazir & Kosar, 2007). In yet another previous study to measure gender related differences of anaerobic power output in subjects with chronic obstructive pulmonary disease it was determined fat-free mass in the legs of subjects was 27% lower in women than in men (Yquel & Tessonneau, 2006). Fat-free mass does not have to specify muscle; bone is also involved, but we well know the ratio of fat-free mass to fat in the lower body should be a reliable indicator of Type I and II muscle fiber activation, hence: power.

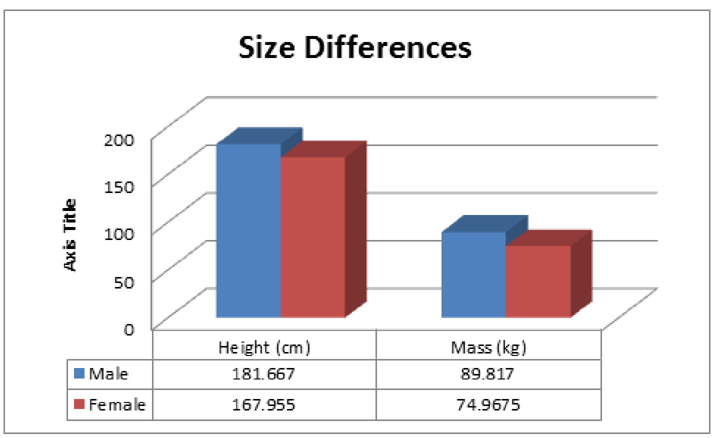

Figure 1: Size Differences Between The Genders

Methods

Subjects

Ten non-elite athlete males (age 27.1 yrs., height 181.67 cm, weight 89.82 kg) and eight non-elite athlete women (age 24.13 yrs., height 167.95 cm, weight 74.97 kg) of the University of Texas at Arlington volunteered to participate in this study. By design, the study took place at approximately 6pm to 8pm. Because of the time of day the study took place it is assumed each subject had several meals worth of energy and arousal levels were high.

Each subject contributed data in the three exercise assessments, which measure anaerobic power output (Wingate Test, Vertec vertical jump test, Force Plate). At the conclusion of each test subjects were given ample time to recover before beginning the next test. The participants in this study were provided with an overview of the study. All testing took place in the exercise laboratory of the kinesiology department of the Maverick Activity Center.

Protocol

Subjects were randomly divided and assigned to a particular starting exercise assessment at random order. Each subject preformed a power output test using Force Plate technology, which displays the power measurements digitally. In the Force Plate test subjects stand still on the measurement pad so it can record subject weight and calibrate any static imbalances. Then, the subject jumps as high as they can from the plate and land back onto it for the Force Plate to read the power output. Subjects also performed a vertical jump test with equipment designed by Vertec. In this test subjects measure their standing reach, then subtract that amount from three trails of a standing vertical jump. The results of the Vertec were used in each formula designed to measure anaerobic power. The formulas are the Lewis, Sayer, Harman and Johnson formulas. The Lewis formula or nomogram (Fox & Mathews, 1974) is a commonly used formula (found in many high school text books). This formula only estimates average power, and is based on a modified falling body equation. The original formula used the units of kg·m·sec.-1. To convert it to Watts, the standard unit for Power, the factor of 9.81 has been added. The Lewis Formula expressed is: Average Power = (square root of 4.9) x body mass (kg) x (square root of jump distance(m)) x 9.81. To improve on the limitations of the Lewis formula, Harman et al. (1991) established equations for both peak and average power through multiple regression procedures.

The Harman Formulas are as follows: Peak power (W) = (61.9 x jump height (cm)) + (36 x body mass (kg)) + 1822. And, Average power (W) = (21.2 x jump height (cm)) + (23.0 x body mass (kg)) – 1393. The Sayers Equation (Sayers et al. 1999) also estimates peak power output (Peak Anaerobic Power output or PAPw) from the vertical jump. The Sayre Formula expressed is: PAPw = (60.7 x jump height (cm)) + (45.3 x body mass(kg)) – 2055. Johnson (1996) also developed a formula for the calculation of peak and average power from the vertical jump test, using the countermovement jump. These equations use the additional factor of body height.The Johnson Formula is as follows: Peak power (W) = (78.6 x VJ (cm)) + (60.3 x mass (kg)) - (15.3 x height (cm)) - 1308. And, Average power (W) = (43.8 x VJ (cm)) + (32.7 x mass (kg)) - (16.8 x height (cm)) + 431.Subjects also performed a Wingate test, which also displays the power output as well as fatigue rate. In the Wingate test subjects peddle as fast as they can for 30 seconds after a warm-up of pedaling at 80 rotations per minute for 30 seconds. The Wingate is inherently flawed when it comes to accurately measuring pure power and accounting for all other forms of variance. Past studies using the Wingate to measure anaerobic power in males and females have confirmed this argument. Since peak power and mean power are size-dependent, [the Wingate] is not a proper approach to express the power outputs per unit of body size variables in comparing individual differences (Hazir & Kosar, 2007). At the conclusion of each test subjects were given ample time to recover before beginning the next test. For the results of the Vertec subjects preformed their own power calculations using said formulas. The entire study took place over the course of 2 hours.

Each subject preformed a countermovement jump power output test using Force Plate technology. The Force Plate measures ground reaction forces. The Force Plate displays the power measurements on-screen without the need for hand-written calculations, thus reducing the effect of human-error. In the force plate test subjects stand still on the measurement pad so it can record subject weight and calibrate, thus accounting for static imbalances. Then, the subject jumps as high as they can from the plate and land on it for it to read the power output. Subjects also performed a vertical jump test with equipment designed by Vertec. The vertical jump is a true anaerobic power-measuring device because this assessment requires far less than 10 seconds of physical activity. In this test subjects measure their standing reach in inches, then subtract that amount from three trails of a standing vertical jump. The results of the Vertec were used in each formula designed to measure anaerobic power. For the results of the Vertec subjects preformed their own power calculations using said formulas. Subjects also performed a Wingate test. Specifically the Wingate measures anaerobic capacity, which is the mean power output, achieved during our exercise bout of 30 seconds. The Wingate also displays the anaerobic power output as well as fatigue rate.

Statistical Analysis

Mean values, maximum and minimum values as well as the standard deviations of the Age (yrs.), Height (cm), Mass (kg), Force Plate, Vertical Displacement (cm), Average Power (W), Peak Power (W), Average Power/kg, Peak Power/kg, Vertec Vertical Displacement (cm), Lewis Power, Sayer Peak Power, Harman Peak Power, Harman Average Power, Johnson Peak Power, Johnson Average Power, Wingate Average Power, Peak Power, Average Power/kg, Peak Power/kg, Time to Peak (seconds), Rate of Fatigue (W/seconds), were calculated for each of the variables. Correlation of the results was run on a Microsoft Excel spreadsheet to find the relationship strengths between the variables. ANOVA and gender-based T-tests were used in SPSS 2012 statistics software to accept and reject the null hypothesis, which stated there is no difference in anaerobic power output between the genders.

Results

The anaerobic power output differences between the genders were significant in certain areas while there was no significance in other areas. The null hypothesis states there is no difference in anaerobic power output between the genders. Because the gold standard is the Force Plate we first consider the findings from that assessment and base all other anaerobic power output finding on the results from the Force Plate. The distribution of the countermovement among males to females (A: 42.3, 24.88 ± 9.05, 7.64) rejects the null hypothesis (P= 0.003). The distribution of Peak Power among males to females (A: 5365.3, 3123.85±1088.459, 884.685) rejects the null hypothesis P= 0.001). The distribution of Peak Power/W/kg among males to females (A: 58.31, 39.70 ±9.353, 12.249) rejects the null hypothesis (P= 0.009). The data did support the null hypothesis in the areas of average power and average power/W/kg.

Within the findings from the Vertec vertical jump test we find only significant differences. We reject the null hypothesis across the board in the displacement category (P=0.006), Lewis Power (P= 0.011), Sayer Power (P= 0.002), Harman Peak and average power respectively (P= 0.001, 0.000), and Johnson Peak power and average power respectively (P=0.002, 0.027). Two of the largest discrepancies in the male to female comparison were in the Sayer Power formula and the Harman average. The distribution of Sayer Power among males to females (A: 5559.14, 3898.10 ±705.646, 764.737) showed the difference was significant. The distribution of the Harman average among males to females (A: 1912.08, 1143.44 ±322.491, 248.240) showed the difference was significant.

The primary finding of other studies was that power production values from the Wingate anaerobic cycle test are dependent upon the resistance used during the test. The greater the resistance in the Wingate test, the greater the power produced. From a performance standpoint, male cyclists are capable of producing greater absolute power during a 30-second sprint using a higher resistance with only a slightly greater rate of fatigue (Richmond et al, 2011). Our Wingate test findings rejected the null hypothesis in the categories of average power (P= 0.000), peak power (P= 0.000), average power/kg (P= 0.000), peak power/kg (P= 0.027). The Wingate findings declared there was no significant difference in the categories of the time to peak measurement or the rate of fatigue. The three categories with the highest significant data among males to females all reject the null hypothesis. They are average power (A: 1022.20, 568.13 ±225.513, 93.250), peak power (A: 1544.80, 1059.38±246.291, 138.373) and average power/kg (A: 11.64, 7.93 ±.630, .411).

In addition to finding significant difference in anaerobic power output between the genders, the study also showed the strength of comparison between the different power measuring tests. The strength of the relationship of anaerobic power is given in terms of a correlation coefficient (r). The Force Plate test is considered the "gold standard". The correlation of the Force Plate peak power and the Wingate peak power is r = 0.83726. This is considered a high relationship. The correlation of the Force Plate average power and the Wingate average power is r = 0.62072.This represents only a moderate relationship. The correlation of the Force Plate and the Lewis formula run on the Vertec results is r =0.5949, moderate relationship. The correlation of the Vertec and the Sayer formula run on the Vertec results is r = 0.81509, another high relationship. Correlations along with other figures and tables comparing data can be found in the appendix.

Table 1: Subject Demographic Data (all subjects, n=18)Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
Age	18	17	22	39	25.78	4.278
Gender	18	1	1	2	1.44	.511
Height	18	36	158	193	175.57	10.081
Mass	18	55	62	117	83.22	14.039
Valid N	17					

Table 2: Force Plate T-Test Comparison data (female n=8, male n=10)Force Plate

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Vertical Displacement	Male	10	42.30	9.050	2.862
	Female	8	24.88	7.636	2.700
Ave. Power	Male	10	2361.14	765.661	242.123
	Female	8	1592.66	554.638	196.094
Peak Power	Male	10	5365.30	1088.459	344.201
	Female	8	3123.85	884.685	312.783
Ave. Power Wkg	Male	10	26.68	8.437	2.668
	Female	8	21.41	6.911	2.443
Peak Power Wkg	Male	10	60.02	10.552	3.337
	Female	8	42.15	11.461	4.052
Vertec Vertical Displacement	Male	9	58.31	9.353	3.118
	Female	8	39.70	12.249	4.331

Figure 2: Force Plate Average Power (W) (female n=8, male n=10) Comparison data

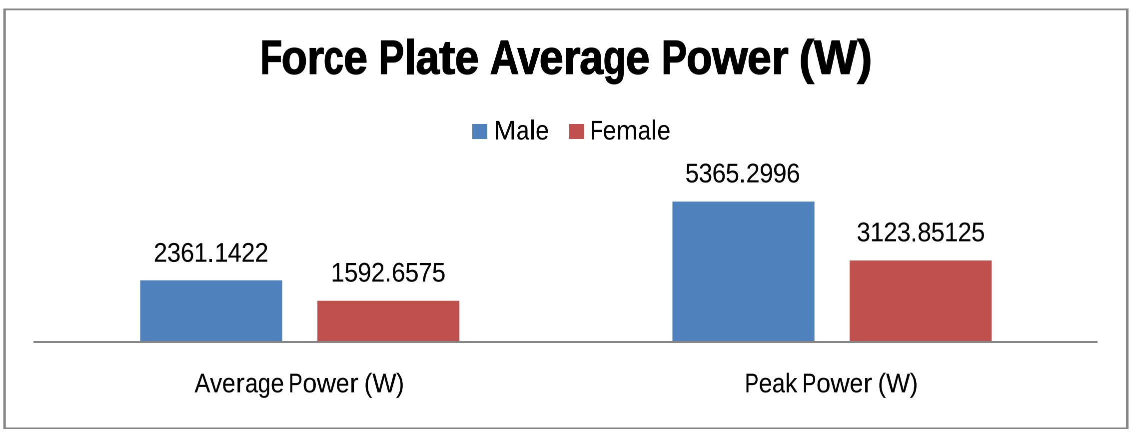

Figure 3: Force Plate Average Power/kg (female n=8, male n=10) Comparison data

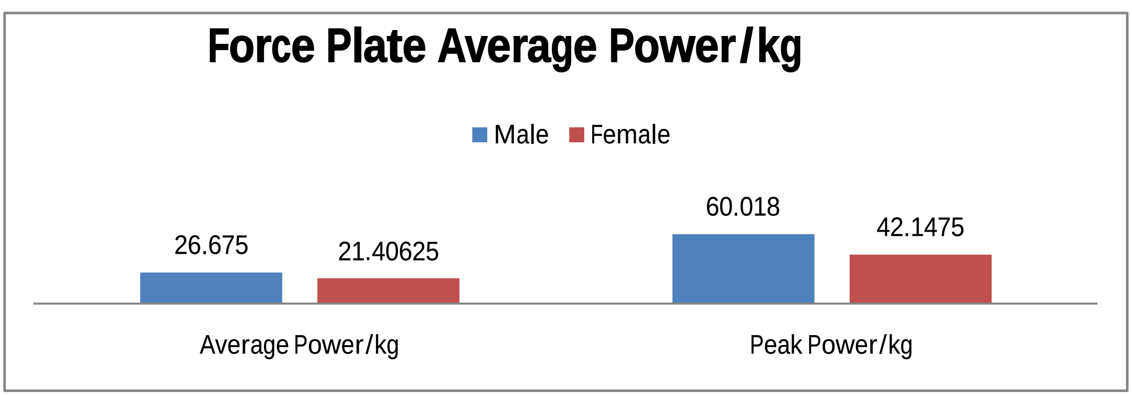

Figure 4: Force Plate Hypothesis Test (female n=8, male n=10)

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of VertDisplace is the same across categories of Gender.	Independent-Samples Mann-Whitney U Test	.003[1]	Reject the null hypothesis.
2	The distribution of AveP is the same across categories of Gender.	Independent-Samples Mann-Whitney U Test	.068[1]	Retain the null hypothesis.
3	The distribution of PeakP is the same across categories of Gender.	Independent-Samples Mann-Whitney U Test	.001[1]	Reject the null hypothesis.
4	The distribution of AvePWkg is the same across categories of Gender.	Independent-Samples Mann-Whitney U Test	.122[1]	Retain the null hypothesis.
5	The distribution of PeakPWkg is the same across categories of Gender.	Independent-Samples Mann-Whitney U Test	.009[1]	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

[1] Exact significance is displayed for this test.

Table 3: Vertec Jump T-Test Comparison data (female n=8, male n=10)

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Vertec Vertical Displacement	Male	9	58.31	9.353	3.118
	Female	8	39.70	12.249	4.331
Lewis Power	Male	9	1509.75	222.939	74.313
	Female	8	1150.28	407.637	144.121
Sayer Power	Male	9	5559.14	705.646	235.215
	Female	8	3898.10	764.737	270.375
Harman Peak Power	Male	9	8669.57	634.745	211.582
	Female	8	6932.32	669.916	236.851
Harman Ave. Power	Male	9	1912.08	322.491	107.497
	Female	8	1143.44	248.240	87.766
Johnson Peak Power	Male	9	5946.95	906.333	302.111
	Female	8	4061.53	870.253	307.681
Johnson Ave. Power	Male	9	1301.60	462.187	154.062
	Female	8	647.12	585.393	206.968

Figure 5: Vertec Jump Displacement (female n=8, male n=10) Comparison data

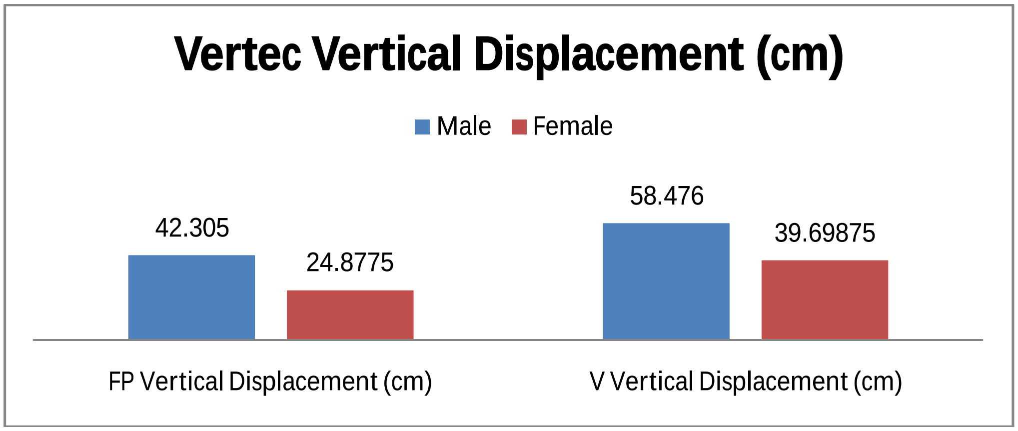

Figure 6: Vertec Jump Hypothesis Test (female n=8, male n=10)Comparison data

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of VertecVertDisp is the same across categories of Gender.	Independent-Samples Mann-Whitney U Test	.006[1]	Reject the null hypothesis.
2	The distribution of LewisP is the same across categories of Gender.	Independent-Samples Mann-Whitney U Test	.011[1]	Reject the null hypothesis.
3	The distribution of SayerP is the same across categories of Gender.	Independent-Samples Mann-Whitney U Test	.002[1]	Reject the null hypothesis.
4	The distribution of HarmanPeak is the same across categories of Gender.	Independent-Samples Mann-Whitney U Test	.001[1]	Reject the null hypothesis.
5	The distribution of HarmanAve is the same across categories of Gender.	Independent-Samples Mann-Whitney U Test	.000[1]	Reject the null hypothesis.
6	The distribution of JohnsonPeak is the same across categories of Gender.	Independent-Samples Mann-Whitney U Test	.002[1]	Reject the null hypothesis.
7	The distribution of JohnsonAveP is the same across categories of Gender.	Independent-Samples Mann-Whitney U Test	.027[1]	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

[1] Exact significance is displayed for this test.

Table 4: Wingate T-Test Comparison data (female n=8, male n=10)

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Wingate Ave. Power	Male	10	1022.20	225.513	71.314
	Female	8	568.13	93.250	32.969
Wingate Peak Power	Male	10	1544.80	246.291	77.884
	Female	8	1059.38	138.373	48.922
Ave. Power kg	Male	10	11.64	1.992	.630
	Female	8	7.93	1.162	.411
Peak Power kg	Male	10	17.90	3.438	1.087
	Female	8	14.75	1.314	.464
Time To Peak	Male	10	3.90	.105	.033
	Female	8	3.90	.214	.076
Rate Of Fatigue	Male	10	42.45	10.762	3.403
	Female	8	37.53	8.041	2.843

Figure 7: Wingate Average/Peak Power (female n=8, male n=10) Comparison data

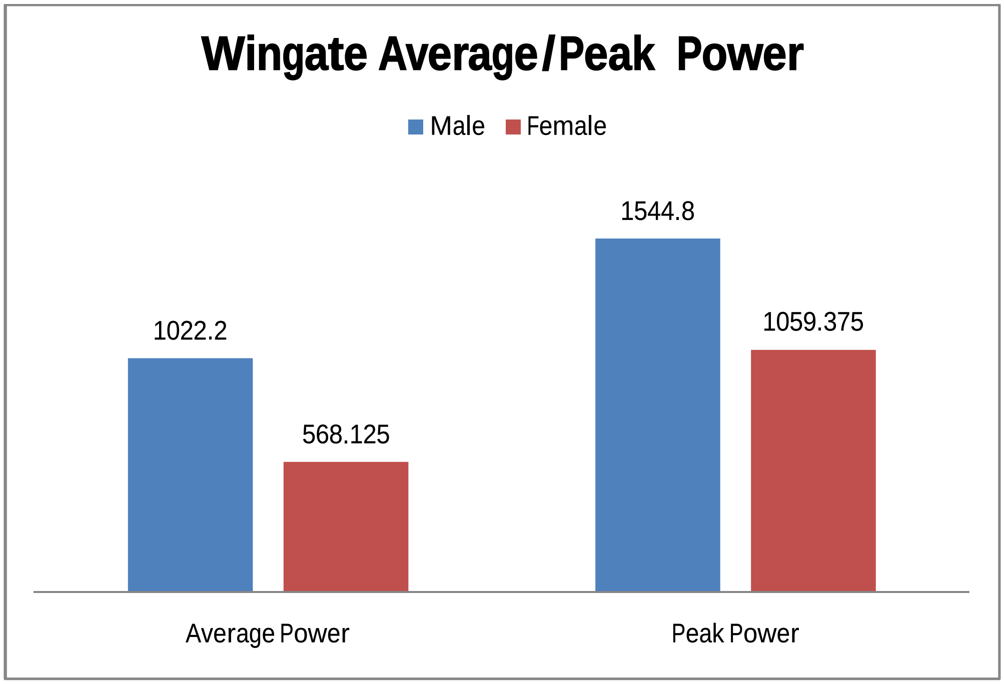

Figure 8: Wingate Comparison data (female n=8, male n=10)

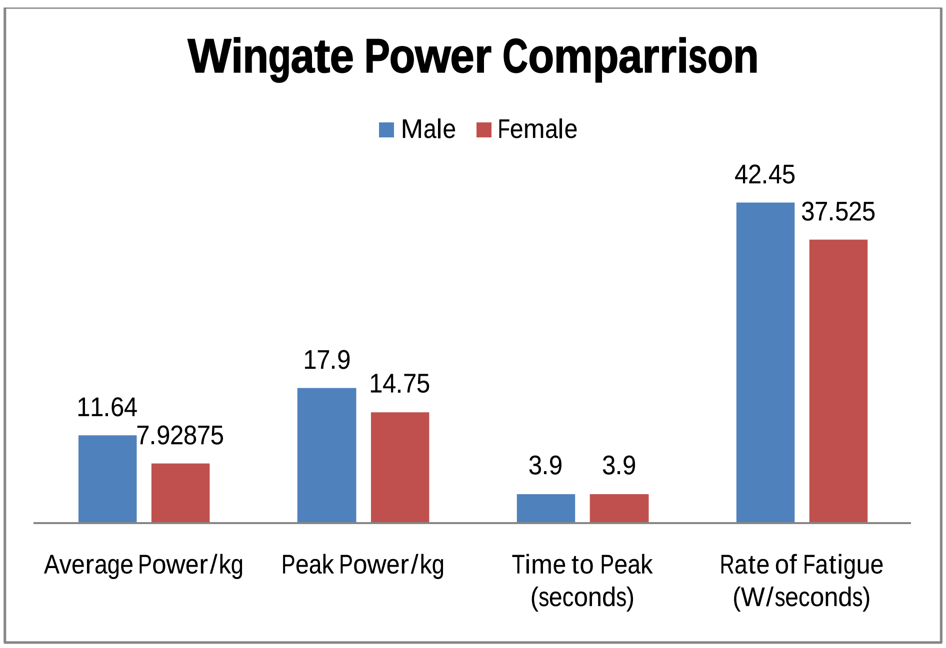

Figure 9: Wingate Hypothesis Test (female n=8, male n=10) Comparison data

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of WingateAveP is the same across categories of Gender.	Independent-Samples Mann-Whitney U Test	.000[1]	Reject the null hypothesis.
2	The distribution of WinPeakP is the same across categories of Gender.	Independent-Samples Mann-Whitney U Test	.000[1]	Reject the null hypothesis.
3	The distribution of AvePkg is the same across categories of Gender.	Independent-Samples Mann-Whitney U Test	.000[1]	Reject the null hypothesis.
4	The distribution of PeakPkg is the same across categories of Gender.	Independent-Samples Mann-Whitney U Test	.027[1]	Reject the null hypothesis.
5	The distribution of TimeToPeak is the same across categories of Gender.	Independent-Samples Mann-Whitney U Test	.515[1]	Retain the null hypothesis.
6	The distribution of RateOfFatigue is the same across categories of Gender.	Independent-Samples Mann-Whitney U Test	.274[1]	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

[1] Exact significance is displayed for this test.

Discussion

The purpose of this study was to determine the difference of anaerobic power output between the genders. As stated previously anaerobic power output can be improved with training. This is why accurate measurement of power is important. In the past, studies have used highly trained athletes to determine improvements in power production. In fact, the purpose of one past investigation was to describe the physiological changes of a nationally ranked older elite freestyle wrestler during a 7-month observation period as he prepared for the 2000 Olympic freestyle wrestling trials (Utter, 2002). The findings suggested near-significant power production differences pre and post-test. If a 33 year old Olympic-hopeful athlete is investing his time into increasing his power after already 20 years of intense training, the average person can expect increasing power from also training accordingly, as the differences will be more extreme and measurable in a less-trained subject. While significant differences were found in power output between the genders it is important to remember power is a ratio of mass to force. Other studies have indicated that the relationships of their findings showed that when individuals with different body sizes are compared, individuals with small body size are disadvantageous in comparing with respect to absolute anaerobic power parameters, on the other hand, large body sized individuals are disadvantageous in comparing with respect to ratio scaled parameters (Hazir & Kosar, 2007). This conclusion was based on the results of WAnT. In other words, the relationships between ratio-scaled anaerobic power indices and the relevant body size descriptors approached zero indicating more dimensionless index compared to ratio scaling. Therefore, analysis should be considered as a method to account for the influence of body size in intergroup and gender comparisons of anaerobic performance (Hazir & Kosar, 2007). Again, this is in accordance with what was predicted. Furthermore, we have found significant gender differences in peak power and mean power revealing that other factors in addition to body dimensions accounts for the gender differences in anaerobic power.

This result suggests that no method adequately adjusts for the gender differences and thus the best methods for studying physical performance of males and females would be separately. Other studies used in research suggest a similar result. In terms of the highly affective Wingate test, when using the lighter resistance (0.080 kg/kgbw), power production for males was greater than almost all previously reported findings by approximately 10 to 30%. When using the heavier resistance (0.095 kg/kgbw), the increase in power production in males was even greater (Richmond et al, 2011). The previously mentioned formulas express this difference in both mass and resistance load. Using the exercises to measure anaerobic power that possess the highest correlations to the Force Plate and correlate highly with the power formulas will give the user the most valid research yielding the most credible data.

Furthermore, the results of this study, based on the understanding that the Force Plate is the gold standard, indicated the Lewis formula on the results of the Vertec test is less ideal than using the power output results of a Wingate test. Both are less ideal than using the anaerobic power output data from a Force Plate test. Because the Force Plate test requires sophisticated technology, hence ample amounts of money, and the proper setting and trained user of the technology to initiate the test, a less-expensive option to measure the anaerobic power output that still has a high correlation with the force plate is the Vertec vertical jump test with the Sayer formula used on those results.

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Appendix

Figure 10: Subject Demographic Data (all subjects, n=18)

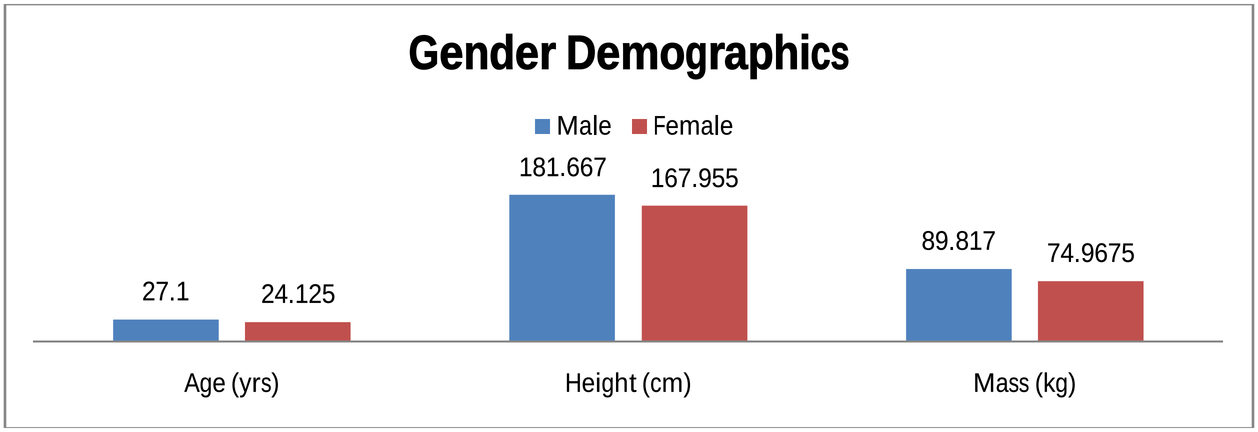

Table 5: Subject Demographic Data(Caucasian, all male, n=10)

Descriptive Statistics For Only Males

	N	Range	Minimum	Maximum	Mean	Std. Deviation
Age	10	16	23	39	27.10	4.654
Gender	10	0	1	1	1.00	.000
Height	10	23	170	193	181.67	7.052
Mass	10	42	76	117	89.82	13.597
Valid N	10					

Table 6: Subject Demographic Data(all female, n=8)

Descriptive Statistics For Only Females

	N	Range	Minimum	Maximum	Mean	Std. Deviation
Age	8	10	22	32	24.13	3.314
Gender	8	0	2	2	2.00	.000
Height	8	23	158	180	167.96	7.968
Mass	8	28	62	90	74.97	10.048
Valid N	8					

Figure 11: Force Plate Comparison Data (female n=8, male n=10)

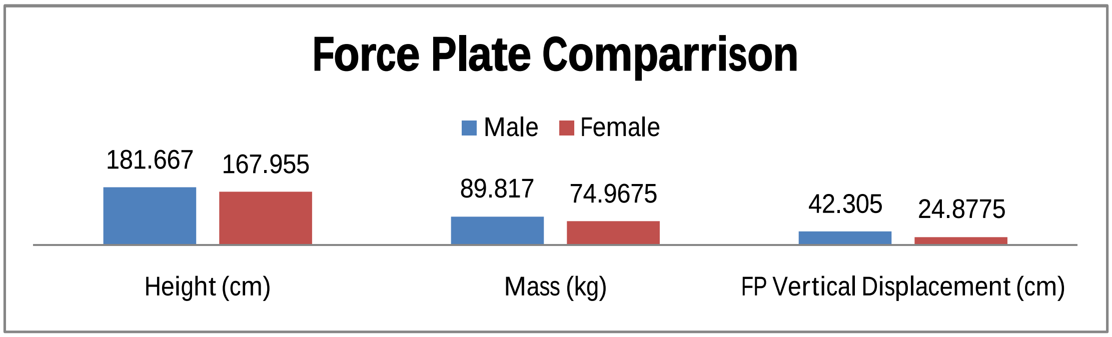

Table 7: Wingate T-Test Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Wingate Ave. Power	Equal variances assumed	8.702	.009	5.317	16	.000	454.075	85.396	273.044	635.106
	Equal variances not assumed			5.780	12.523	.000	454.075	78.566	283.684	624.466
Wingate Peak Power	Equal variances assumed	2.094	.167	4.964	16	.000	485.425	97.785	278.129	692.721
	Equal variances not assumed			5.278	14.584	.000	485.425	91.974	288.898	681.952
Ave. Power kg	Equal variances assumed	3.678	.073	4.657	16	.000	3.711	.797	2.022	5.400
	Equal variances not assumed			4.935	14.834	.000	3.711	.752	2.107	5.316
Peak Power kg	Equal variances assumed	6.901	.018	2.441	16	.027	3.150	1.291	.414	5.886
	Equal variances not assumed			2.664	12.068	.021	3.150	1.182	.576	5.724
TimeToPeak	Equal variances assumed	1.270	.276	.000	16	1.000	.000	.077	-.163	.163
	Equal variances not assumed			.000	9.702	1.000	.000	.083	-.185	.185
RateOfFatigue	Equal variances assumed	1.060	.318	1.074	16	.299	4.925	4.585	-4.795	14.645
	Equal variances not assumed			1.111	15.954	.283	4.925	4.434	-4.478	14.328

Figure 11: Correlation Comparison data (n=18)