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COMPARISON OF A FOUR 40-YARD SPRINT TEST FOR ANAEROBIC CAPACITY IN MALES VS. THE WINGATE ANAEROBIC TEST

by

PETER CHRISTIAN JOHNSON

(Under the Direction of Jim McMillan)

ABSTRACT

Modern sports require quick, powerful movements to be successful, and as a result anaerobic ability is of interest. A number of tests exist for the measurement of anaerobic parameters, but none have achieved a "gold-standard" status. The Wingate Anaerobic Test (WAT) has received widespread support and is among the most widely accepted (Bar-Or, 1987; Hoffman, Epstein, Einbinder, & Weinstein, 2000; Sands et al, 2004). The WAT is a cycle-based test however. Sprint-based field tests are more practical to administer and are more specific to the requirements of many sports, but the standards used are anecdotal, and while shown to be reliable (Moir, Button, Glaister, & Stone, 2004 ; Thomas, Plowman, & Looney, 2002), their validity has been questioned (Seiler et al, 1990). This study compares a test of four 40-yard sprints through measurement of blood lactate concentration generated by each test and power calculations.

INDEX WORDS: Anaerobic power, Wingate, Field test, Lactate

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PETER CHRISTIAN JOHNSON

B.S., Virginia Military Institute, 2005

A Thesis Submitted to the Graduate Faculty of Georgia Southern University in Partial Fulfillment of the Requirements for the Degree

MASTER OF SCIENCE

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# COMPARISON OF A FOUR 40-YARD SPRINT TEST FOR ANAEROBIC CAPACITY IN MALES VS. THE WINGATE ANAEROBIC TEST

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| Major Professor: | Jim McMillan |
| Committee: | Barry Joyner<br>Matthew Williamson<br>Steve Rossi |

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# CHAPTER 1

# INTRODUCTION

Due to the nature of modern sports, anaerobic power and capacity is of great interest to those involved with them, as most rely heavily on athletes' ability to move quickly and powerfully. Many different tests of anaerobic power and capacity are in use today. Sprint running times have been shown to be well correlated to peak and mean power output (Tharp, Newhouse, Uffelman, Thorland, & Johnson, 1985; Patton & Duggan, 1987). While sprint tests have been shown to be reliable measurements (Moir, Button, Glaister, & Stone, 2004; Thomas, Plowman, & Looney, 2002), the protocols and standards used for interpreting results are based on anecdotal evidence, and their validity has been questioned (Seiler et al, 1990). In contrast, the Wingate Anaerobic Test (WAT) has been shown to be valid and reliable (Bar-Or, 1987) and is a widely accepted test of anaerobic capacity and power. The WAT, however, is a laboratory test requiring trained personnel and a cycle ergometer that can provide enough resistance to test the participant. In addition, cycling is less sport-specific for many sports when compared to sprint-based tests. In previous research, it seems that anaerobic testing results seems to be specific to the activity being performed; varied results have been obtained from jump and run based tests versus the WAT (Seiler et al; Sands et al, 2004; Hoffman, Epstein, Einbinder, & Weinstein, 2000). Thus it seems that for athletes, tests of anaerobic power should be as sport specific as possible to obtain accurate results for athletics. An accurate sprint-based field test would be of more use and relevance than a cycle-based test in most athletic settings. In addition to being useful in athletics, such a test would require a minimum of trained personnel and laboratory equipment, making it ideal for situations where these resources are unavailable, or where laboratory testing is impractical.

The purpose of this study was to compare a test of four 40-yard sprints with the WAT. Blood lactate concentration ($[La]_b$) was examined between tests for physiological evidence of a maximal test for capacity. Rating of perceived exertion (RPE) was measured on the Borg 6-20 scale for volitional exertion. Peak power (PP) and mean power (MP) outputs were computed for each test to allow for direct comparison between tests in Watts, as opposed to correlation between Watts in the WAT and seconds in the sprint test.

# CHAPTER 2

# REVIEW OF LITERATURE

Anaerobic testing has been of considerable research interest in relatively recent times. Various tests have been proposed and implemented, including sprint tests, cycle-ergometer tests, stair climbing tests, and jumping tests. There is not a "gold-standard" anaerobic test, as $VO_2$ measurement is with aerobic performance testing, but the WAT has considerable support and is widely accepted as a laboratory standard (Bar-Or; Hoffman et al; Patton & Duggan; Sands et al; Tharp et al). Of the studies reviewed that compare anaerobic tests, all compare anaerobic tests to WAT performance, and only two do not specifically compare sprint test performance to the WAT.

Sands et al compared the WAT to the jump-based Bosco anaerobic test. WAT resistance was set at 7.5% of participants' body mass. The Bosco test involves repeated jumping from a force platform. Participants were instructed to make rapid, continuous jumps of maximum attainable height throughout a 60-second period. Subjects were instructed to lower to a position of approximately 90° of knee flexion before each jump as well as keep their hands on their hips throughout the test to minimize the contribution of the upper body during the test.

Their sample consisted of eleven men aged $21.36 \pm 1.6$ years and nine women aged $21.89 \pm 3.66$ years; all were NCAA intercollegiate athletes at Eastern Washington University, with most being track and field athletes. Blood lactate concentration was measured to assess anaerobic energy demands between the two tests, and correlations were computed for peak lactate concentrations between tests, and for lactate values with peak and average power. Using a randomized testing order, all tests were conducted with a minimum of 24 hours recovery time between. Prior to each test, blood samples were taken via finger-prick to obtain resting blood lactate levels. Samples were again taken following testing at 3, 5, 7, 9, and 11 minutes to ensure that a true peak value would be recorded; an Accusport Portable Lactate Analyzer was used for testing (Sports Resource Group, Boehringer Mannheim, Indianapolis, IN). The results indicated that while peak lactate values were statistically higher in men, there was no significant difference in values between tests, nor was any sex-test interaction observed. Pearson's product-moment correlations were calculated between sexes separately due to the initial significant difference in blood lactate values. These results indicated that there was no significant correlation between peak lactate values on either test for either sex. There were also no significant correlations between peak or average power and peak lactate values for either sex for either test.

In this sample, average power for males and females on the Bosco test was significantly higher than WAT when expressed in absolute and relative ($W \cdot kg^{-1}$) terms, as well as allometrically scaled for body weight ($W \cdot kg^{-0.67}$). Peak power ratings were also significantly higher on the Bosco test for males and females in all three methods of expression. Among relative power calculation correlations, the only significant correlation observed was for males on average power between tests. Peak power correlations were not significant between tests for males; neither correlation was significant between tests for females. When power was expressed in absolute terms, females showed a significant correlation between tests for average power, but peak power correlations were not significant. For males, both peak and average absolute power correlations were significant between tests.

From these results, they concluded that while the Bosco and Wingate tests both measure anaerobic energy production, they appear to measure different aspects of anaerobic power and capacity. They went on to speculate that the Bosco test may be inappropriate for individuals with little or no jump training, and that some of the differences observed in anaerobic power and capacity scores may be explained by the Bosco test's extensive use of the stretch-shortening cycle, which is not a factor on the WAT.

The Omnikinetic™ dynamometer is a lower body dynamometer that can be used to evaluate anaerobic power. This device places the participant in a semirecumbant position while performing a stepping motion on the device; single leg power outputs may be calculated and summed to get total output. The range of motion at the hip, knee and ankle are similar to values reported during cycling. Typical ranges of motion during testing for the hip, knee, and ankle were $46 \pm 4$, $76 \pm 5$ and $16 \pm 3°$ respectively.

Dolny, Collins, Germann, Phipps, & Davis (2000) compared WAT results to Omnikinetic™ results in their paper. The study had ten male participants, aged $24 \pm 3$ years. All had participated in aerobic training at least 4 times per week, and 7 had resistance trained 2-3 times per week for at least six months prior to the study. At least 48 hours occurred between WAT and Omnikinetic™ testing phases, and participants were instructed to abstain from exercise for 24 hours prior to each phase. Both phases were completed within 5 days of each other.

Statistically, Dolny et al computed Pearson product-moment correlations to compare peak and average power output between the two tests, in both absolute and relative terms, as well as fatigue index and fatigue slope.  Power outputs on the Omnikinetic™ were the sum of right leg and left leg power outputs. Dolny observed significantly higher WAT peak power in both absolute and relative terms. Despite differences, significant correlations were found between peak and mean power in both absolute and relative terms between the two tests, with *r* values ranging between 0.70 and 0.84.

They speculated the difference observed in peak power between the two tests may have been due to differences in body position. The upright cycling provided greater mechanical advantage, since the general direction of hip and knee extension was downwards, whereas on the Omnikinetic™ machine, force was applied more horizontally. Also, they noted that only concentric power is measured by the device; eccentric power is required to decelerate the backward movement of the crank on each leg back to its starting position. They cited that this may be as much as one-third of the power generated during extension, but this force is not measured by the device. Finally, they stated that the resistance setting on the Omnikinetic™, which was equal to the participants' body weight, based on an unpublished pilot study conducted by the same author, may have been suboptimal for peak power development, but adequate for mean power development. This is consistent with findings on the WAT that greater resistances are necessary to elicit peak power development, and is collaborated by noting that the observed fatigue indices were significantly lower on the Omnikinetic™ device.

Dolny et al concluded that the Omnikinetic™ device may be useful in evaluating mean power, and after further research may be useful in evaluating peak power as well. He went on to point out advantages of the device that included the ability to calculate individual leg outputs, which may be useful for evaluating athletes in sports that require different leg power characteristics, as well as during rehabilitation of injured persons. Also, the test allows for joint movement speeds similar to those observed in sprinting and vertical jumping, which allows for more specific testing.

Tharp et al (1985) compared results of timed runs of 50 and 600 yards, as well as vertical jump and standing long jump tests with WAT results in boys aged 10-15 years. Mean age in the study was 13.26 $\pm$ 1.20 years. Participants ranged from non-athletes to national caliber runners. Tharp found significant correlations between all of these tests and anaerobic capacity as measured by the WAT, except for the 600-yard run. 600-yard run times adjusted for weight did provide a significant correlation however. The reported a stronger correlation between the 50-yard run versus the 600-yard run with anaerobic capacity results on the WAT is not surprising. The authors stated that the 600-yard run involved a significantly larger aerobic component. While Tharp's correlations were significant, they only revealed moderate correlations. 50-yard run times had a Pearson's R of -0.53 for both power and capacity; when times were adjusted for weight, Pearson's R was found to be -0.68 for capacity and -0.66 for peak power. They concluded that the WAT was only a moderate predictor of sprint times, which supported the need for a more specific anaerobic power test.

Tharp et al. only made comparisons between the WAT and a single 50-yard sprint, which took participants 6.95 $\pm$ 0.54 sec to complete; due to the short nature of this test, it was unlikely that it was a maximal anaerobic test for mean power output, but may serve as a reasonable test for peak anaerobic power. This suggested the need for further research to find an anaerobic capacity field test.

Seiler et al. (1990) compared several popular field tests to both the WAT and the Margaria-Kalaman test, a stair-stepping based test for anaerobic power. The field tests compared included the 5- and 35-yard sprint, the standing five-jump test, the vertical jump, and the standing long jump. The times for the 5 and 35-yd sprint were recorded in the same trial, with participants completing a 40-yard sprint with splits measured at the initial 5-yard mark and the subsequent 35 yards. For statistical use, 5- and 35-yard sprint times were converted to velocities in m/s.

Forty-one males (aged 20.56 $\pm$ 1.19 years, weighed 98.2 $\pm$ 16.43 kg, and had 12.7 $\pm$ 3.56 percent body fat), all members of the University of Arkansas intercollegiate football team, participated in testing that occurred at the conclusion of a ten week off-season strength and conditioning program. The investigation's results yielded several significant correlations. In relation to WAT results, all of the field tests were significantly correlated to peak and mean power. The strongest correlation was observed between the vertical jump and WAT peak power, at $r = 0.75$. Sprint time correlations to WAT peak power were $r = 0.54$ and $r = 0.73$ on the 5- and 35-yard sprints, respectively. In relation to WAT mean power, correlations were $r = 0.54$ and $r = 0.62$ for the 5- and 35-yard sprints respectively.

These correlations were similar to those found by Tharp et al, who reported only moderate relationships between sprint ability and WAT performance. Again, only one trial of a 40-yard sprint test was used to assess anaerobic capabilities, which was almost certainly not a maximal capacity test, especially in the population that Seiler employed.

Hoffman et al. (2000) also compared run times to WAT performance. Field tests of a single countermovement vertical jump (CMJ), a 15-second anaerobic jump test (APJT), and a sprint test known as the "line drill" were compared to the WAT. The line drill, also commonly referred to as "suicides," consists of a continuous 143.4-m sprint with several changes of direction. The test was conducted on a regulation basketball court. Participants began at one baseline, and sprint to four points on the court, one on the near free-throw line, one on the half court line, one on the far free-throw line, and one on the far baseline. After sprinting to each point, the participant sprinted back to the starting position before continuing the test. The line drill was performed in three trials with two minutes of recovery between each trial.

Subjects included nine volunteers from the Israeli National Youth basketball team. Mean age was 17.0 $\pm$ 0.0 years, mean weight was 85.1 $\pm$ 6.0 kg, and mean height was 191.7 $\pm$ 5.7 cm. Mean body fat percentage was 11.9 $\pm$ 3.1%. Testing occurred during the first week of national team practice, which occured 1 week following the conclusion of the basketball regular season, so it was assumed that all participants were in good condition.

Their results showed that the three subjects with the fastest line drill times also had the highest mean power output and vertical jump. Conversely, the three slowest participants had the poorest scores for mean power output and vertical jump. Hoffman used the Kendall Tau rank correlation to relate the tests; significant positive correlations were found between CMJ and trails 1 and 2 of the line drill, as well as between APJT and trials 2 and 3 of the line drill. Significant correlations were also found between mean power on the WAT and trials 1 and 2 of the line drill, $\tau = 0.61$ and $\tau = 0.54$ respectively. CMJ was significantly correlated to mean and peak power. Peak power scores were not significantly correlated with line drill times, and APTJ were not significantly correlated to mean or peak power on the WAT.

Hoffman et al. concluded in their paper that the correlations observed between the WAT mean power scores and line drill performance suggest that the line drill may be an acceptable field measure of anaerobic power. They explained the stronger correlation between mean power and the line drill as being a result of the relatively longer distance of the line drill, whereas a shorter distance may be more appropriate for peak power.

Patton & Duggan (1987) also compared a number of tests. In their study, they compared anaerobic capabilities by looking at results from an isokinetic endurance test, the Margaria-Kalaman test, the WAT, and sprints of 50- and 200-m. The data were collected over a two-week period, with test familiarization occurring the first week, along with the WAT and isokinetic testing occurring on separate days. During the second week, the Margaria-Kalaman test and the sprint test were conducted on separate days.

Their sample was 14 male soldiers of the British Army Personnel Research Establishment trails section. Ages ranged between 20 and 34 years. Mean height was

173.7 $\pm$ 6.7 cm, mean weight was 76.5 $\pm$ 7.7 kg, and mean percent body fat was 16.7 $\pm$ 4.6%. Mean $VO_2$ was 49.1 $\pm$ 5.1 $ml \cdot kg^{-1} \cdot min^{-1}$.

Calculated correlations with WAT performance were slightly stronger in this study, due to the use of two sprints of different distances. The strongest correlations found were observed with WAT results expressed in weight-relative terms. For relative mean power on the WAT, correlations were $r = -0.790$ and $r = -0.819$ for the 50- and 200-m sprints respectively; both correlations were significant to p-values of less than 0.001. For relative peak power, correlations were $r = -0.706$ and $r = -0.540$ on the 50- and 200-m sprints respectively. 50-m results were significant to $p > 0.01$, while 200-m results are significant to $p > 0.05$. Patton & Duggan concluded that the Wingate may be a good predictor of sprint run times, especially when expressed relative to body weight.

Thomas et al (2002), compared the WAT to two running tests, the Anaerobic Speed Test (AST), a laboratory treadmill test, and the Field Anaerobic Shuttle Test (FAST), a field test used by some soccer coaches. Thomas et al investigated the reliability of these two particular tests, as well as their validity against the WAT.

AST protocol was fairly simple. Participants had five practice trials in one session at least 48 hours but no more than 7 days before any actual testing. Participants were fitted with and familiarized with the Safe/Stress Harness system, which automatically reduced treadmill speed and grade if the participant failed to keep pace with the treadmill. Practice trials had varying grades and speeds; between 2.0 mph and 0% grade and 8 mph and 20% grade. Practice trials also only consisted of 10-20 seconds of running, as compared to 30-60 seconds expected until fatigue in actual testing. During actual testing, participants were fitted with the Safe/Stress harness, and the treadmill was set to 6.5 mph and 0% grade for a 5-minute warm-up. After 3 minutes of rest, the treadmill was set to 8 mph and 20% grade. The participant straddled the treadmill belt until set speed and grade were achieved, and then "jumped" on the belt while holding the hand rails when they were ready. Test timing began when the participant removed his/her hands from the treadmill hand rails, and stopped when the participant supported him/herself with the handrails or the Safe/Stress harness was activated. Verbal encouragement was provided throughout, and timing was made to the nearest 0.1 seconds.

For the FAST, one practice trial was held on a wood-floored gymnasium, where the actual test would be conducted. The practice trial was simply a simulation of the actual test at a slower, jogging pace. The test consisted of running between two markers 20 meters apart. The warm-up consisted of participants jogging between the two cones at a speed of 6.5 mph determined by a pre-recorded cadence for 5 minutes followed by a 3 minute rest. After the rest, the test was administered. From a standing start, on the command of "Go!" the participant ran the 20 meter distance as fast as possible 12 times (6 sprints up and back) with quick direction changes at each end. Time to complete was recorded to the nearest 0.1 seconds, and verbal encouragement was provided.

Testing participants were 13 males and 13 females recruited from various soccer programs in the state of Illinois. Participants came from the Chicago Stingers and Cobras professional teams (n=2), and the Northern Illinois University NCAA Division I men's (n=10) and women's (n=12) and the Kishwaukee Community

College Men's (n=2) teams. Age range was 18-28 years old; overall mean age was 20.4 $\pm$ 2.0 years. Mean male age was 20.4 $\pm$ 2.4 years, and mean female age was 20.2 $\pm$ 1.3 years. Mean statures were: 176.5 $\pm$ 6.7 cm for males, 167.7 $\pm$ 7.2 cm for females, and 172 $\pm$ 8.2cm overall. Mean masses were: 77.5 $\pm$ 8.4 kg for males, 64.4 $\pm$ 7.3 kg for females, and 70.7 $\pm$ 10.8 kg overall. Participants were randomly assigned by sex to one of three groups, and each group performed two trials of the WAT, FAST, and AST. Group 1 performed the WAT, then the FAST, and then the AST for both trials. Group 2 had a testing order of AST, WAT, FAST for both trials, and Group 3 had a testing order of FAST, AST, WAT for both trials. In each trial, subjects rested 1 hour after the WAT and AST before performing the next test, and 30 minutes after the FAST including active cool down. Trials were performed a minimum of 48 hours and a maximum of 7 days apart.

Thomas et al reported moderate to strong correlations between AST and FAST times with WAT mean power, expressed both in absolute and relative terms. FAST correlation with absolute WAT mean power was reported as r= -0.89 and r= -0.9 for trials 1 and 2. Pearson's r= -0.71 for both trials between FAST and relative WAT mean power. AST was correlated with absolute WAT mean power ratings at r= 0.82 and r= 0.79 on trials 1 and 2 respectively. When WAT mean power results were expressed in relative terms, correlations with trials 1 and 2 dropped to r= 0.74 and r= 0.73 respectively. AST and FAST were correlated with each other, r= -0.85 and r=-0.87 on the first and second trials respectively. All correlations were significant.

Thomas et al also examined the reliability of the FAST and AST between trials. No significant differences were found between trials for either test. Intraclass reliability coefficients were found to be 0.96 for the FAST, and 0.97 for the AST. Based on the data obtained from their testing, Thomas et al accepted the FAST and the AST as reliable tests.

Moir et al (2004) examined the effect of familiarization on vertical jump testing and acceleration sprinting. In this study, test participants conducted a series of 5 sprints, as well as vertical jumps with and without countermovement and with and without a load of 10 kg. Each of the five sprints consisted of a 20-m sprint with a 10-m split measured concurrently.

Testing participants were 10 male physical education students. Mean age, weight and stature was 25.3 $\pm$ 6.6 years, 76.2 $\pm$ 9 kg, and 1.75 $\pm$ 0.08 m, respectively. The intraclass correlation coefficient between the five 10-m splits was 0.93, and 0.91 between the 20-m sprints. Based on these data, Moir et al accepted the 10- and 20-m sprints as reliable tests.

The accuracy and precision of the Nova Lactate Plus blood lactate concentration analyzer was also reviewed. The manufacturer’s data stated that in a trial of 210 samples ranging from 0.5 to 12.4 mmol/l lactate concentration, the Nova Lactate Plus yielded a correlation coefficient of 0.997 with the YSI laboratory reference method, indicating a high level of accuracy. Five trials of 20 measurements were carried out to evaluate precision. Each of the five trials had a different known lactate concentration, ranging from 1.6 to 22.1 mmol/l. The trials yielded coefficients of variation ranging from 1.6% to 3.6%, and standard deviations ranging from 0.06 to 0.7.

Overall, it seems that evidence suggests that good agreement should exist between the proposed sprint test and the WAT. Shorter distance sprint times appear to be better correlated with peak power, while longer distance sprint times correlate more strongly with mean power. This supports the use of the fastest 40-yard sprint time for peak power calculation and the mean sprint time for mean power calculation. Similar sprint tests have been accepted as reliable in published scientific studies, and blood lactate concentration has been used previously to compare between tests of anaerobic parameters and examination of anaerobic energy production (Lacour, Bouvat, & Barthelemy, 1990; Sands et al).

# CHAPTER 3

# MATERIALS AND METHODS

## Personnel

For this study, 15 recreationally active college-age (18-24 years, 75.31 $\pm$ 9.25 kg) males volunteered from the Georgia Southern Physical Activity classes. Females were excluded due to evidence of different lactate response on the WAT (Gratas-Delamarche, Le Cam, Delamarche, Monnier, & Koubi, 1994) for study economy.

## Procedures

Prior to initial testing, all participants read and signed an institutional-approved informed consent form (App. C). In addition, before each testing phase, participants signed a statement of ability and willingness to test (App. D), indicating that they were willing, prepared, and capable of testing that day, and knew of no reason that the results they provided that day would be unusable. This form was intended to prevent test results from being skewed due to injury, illness, or other physiological impairment, specifically ethanol intoxication. Blood lactate levels may be abnormally elevated for up to 24 hours following ethanol intoxication (Dudka, Burdan, Korobowicz, Klepacz, & Korobowicz, 2004; Shiraishi Watanabe, Motegi, Nagaoka, Matsuzaki, & Ikemoto, 2003). Testing order was counterbalanced, with each participant completing a sprint test and the WAT at least 48 hours apart to allow for recovery.

For the sprint test, participants were massed and then performed a standardized warm-up protocol (App. E). Following warm-up, participants executed four timed 40-yard sprints interspersed by a 15-second recovery period. This created a total sprint time of slightly shorter than the 30-second WAT; in addition Hirvonen, Nummela, Rusko, Rehunen, & Harkonen (1992) found that the rate of blood lactate accumulation attained the highest level after a similar time of sprint running. Sprinting was done in an indoor gymnasium (22°C, 34% RH). At the completion of the fourth sprint, participants had perceived exertion measured using the 6-20 Borg scale, and were instructed to sit in a chair for recovery. Blood lactate was measured after four minutes; this is approximately the amount of time observed for maximum blood lactate accumulation to occur in 100- and 200-m sprints by Hirvonen et al. Peak power was calculated using the fastest sprint time, and mean power was calculated using the mean of each participant's four sprints.

For the Wingate phase, participants were massed and had the seat, pedals, and handle bars adjusted for optimal performance, and then conducted a three minute warm-up of pedaling against no resistance at a self-selected pace. The participants were instructed to sprint for 2-3 seconds at approximately 1:30 and 2:30 into the warm-up. At the end of the three minute warm-up period, the participant was told to sprint and resistance was quickly, manually adjusted to 7.5% of the participant's body mass. When the desired load was reached, approximately 2-3 seconds after the initiation of the sprint, the 30-second test began and pedal revolutions were counted. After the 30-second sprint, participants were instructed to sit in a chair for recovery, and immediately had perceived exertion measured on the Borg 6-20 scale. After four minutes, blood lactate concentration was measured. Peak power was computed using the highest number of pedal revolutions in any five second period, and mean power was calculated from total pedal revolutions.

Instrumentation

Wingate testing was carried out on a Monark Ergomedic cycle ergometer (Model 818E, Vansbro, Sweden). Blood lactate measurements were made using the Nova Lactate Plus handheld blood lactate concentration analyzer (Nova Biomedical, Waltham, MA). Sprints were hand-timed to the nearest 0.01 sec. using Robic SC-505 digital stopwatches (Marshall-Browning International Corp., Oxford, CT).

Statistical Analysis

Four dependant t-tests were carried out to observe for differences between peak power, mean power, $[La]_b$, and RPE between the tests. Correlations between these variables across tests were also computed. Boneferroni adjusted alpha level was set at 0.0125 to compensate for multiple t-tests. Statistical analysis was carried out using SPSS 15.0 for Windows statistical software package.

# CHAPTER 4

# RESULTS

No significant differences were found between tests for RPE, mean power ratings, or blood lactate concentration, $[La]_b$. RPE means were exactly the same (sprint, 15.600 $\pm$ 1.920 vs. WAT, 15.600 $\pm$ 2.261). Mean power ratings were also approximate to each other (sprint, 513.173 $\pm$ 70.111 W vs. WAT 542.584 $\pm$ 91.480 W). $[La]_b$ may have been found to be significantly different in a larger sample; sprint mean $[La]_b$ was higher than WAT mean $[La]_b$ in this sample (12.867 $\pm$ 2.752 mmol/L vs. 11.087 $\pm$ 2.435 mmol/L, $p = 0.027$, ES = 0.685). Had the p-value not been modified to compensate for the multiple t-tests, this result would have been significant as the study stands. Peak power was found to be significantly higher on the WAT than on the sprint test (753.046 $\pm$ 167.982 W vs. 543.800 $\pm$ 78.246 W, $p < 0.001$, ES = -1.597).

The only significant correlation found was for mean power between tests, $r = 0.773$, $p = 0.001$. Peak power correlation was nearly significant, and may have been so in a larger sample. Peak power correlation was $r = 0.600$, $p = 0.018$.

Mean sprint time for sprint 1 was 5.093 $\pm$ 0.240 seconds; for sprint 2, 5.292 $\pm$ 0.233 seconds; for sprint 3, 5.466 $\pm$ 0.297 seconds; for sprint 4, 5.669 $\pm$ 0.277 seconds. Mean fatigue index for the sprint test was 10.600 $\pm$ 4.050%.

Mean total revolutions for the WAT was 49.067 $\pm$ 5.338 revolutions; peak revolution mean was 11.333 $\pm$ 2.024 revolutions. Mean fatigue index for the WAT was 51.917 $\pm$ 10.874%.

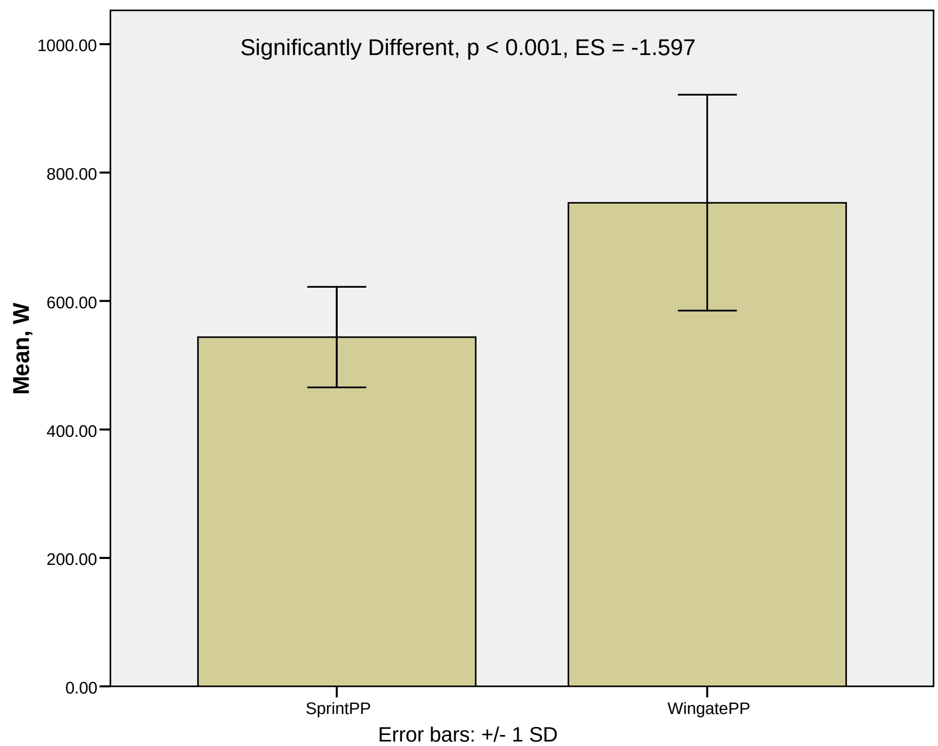


Figure 1: Peak power ratings between tests

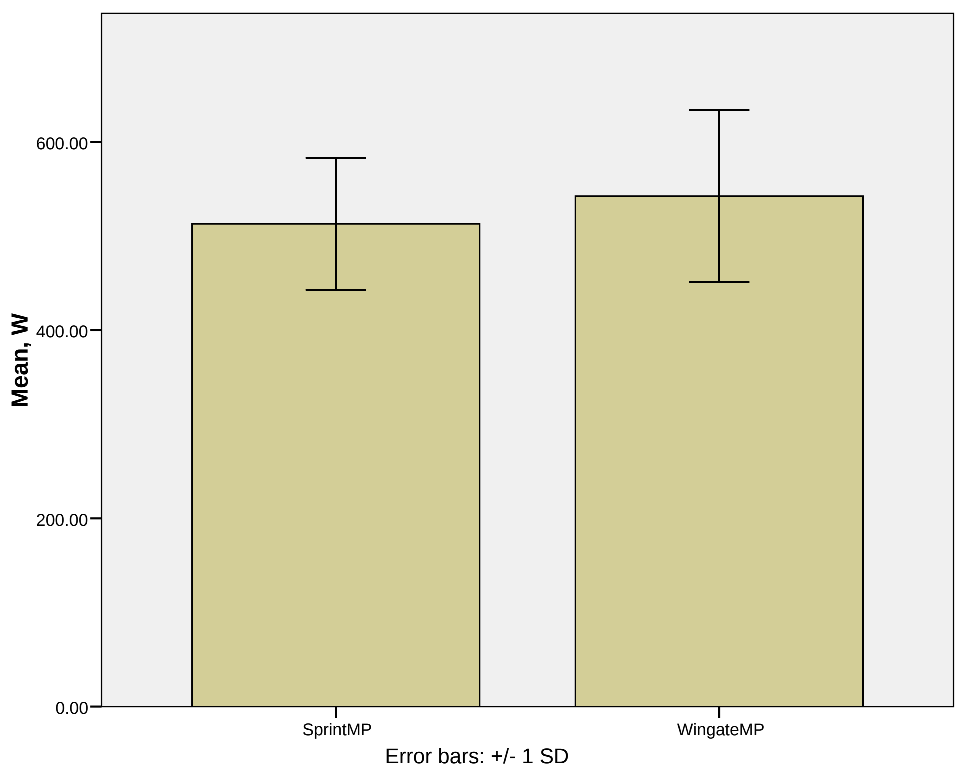


Figure 2: Mean power ratings between tests

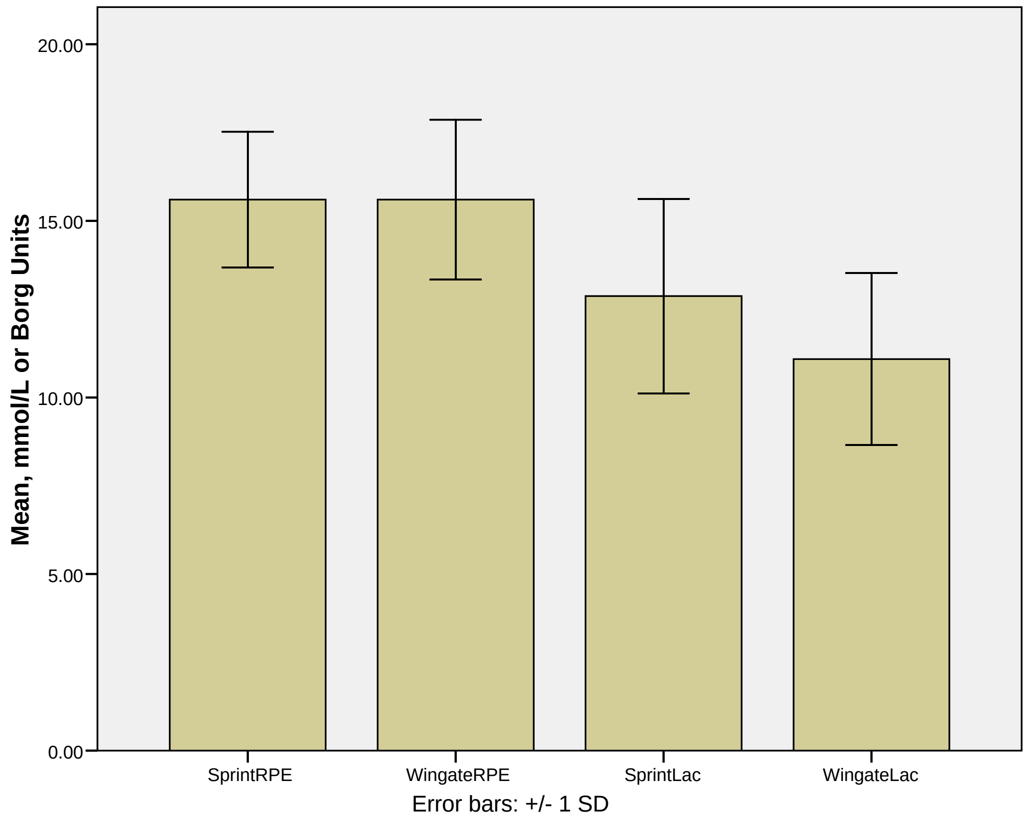


Figure 3: RPE ratings and $[La]_b$ between tests

| Paired Samples Correlations | N | Correlation | Sig. |
|---|---|---|---|
| Sprint RPE & Wingate RPE | 15 | 0.487 | 0.066 |
| Sprint $[La]_b$ & Wingate $[La]_b$ | 15 | 0.425 | 0.114 |
| Sprint PP & Wingate PP | 15 | 0.600 | 0.018 |
| Sprint MP & Wingate MP | 15 | 0.773 | 0.001 |

Table 1: Paired Sample Correlations

# CHAPTER 5

## DISCUSSION AND CONCLUSION

These results indicated that the proposed sprint test may be a useful indicator of mean anaerobic power, but significant evidence also indicated that the single fastest 40-yard sprint was a poor indicator of peak power. With the possible exception of the peak power findings, all of the findings in this study need to be to be confirmed with further research; statistical power ratings for all of the t-tests were unacceptable except for the peak power test. Statistical power ratings for t-tests were: peak power, 98%; $[La]_b$, 32.6%; mean power, 9%; RPE, 1%.

It is possible that the peak power difference existed due to the differences in resistance between the tests. In the WAT, only 7.5% of the participant's body mass was being acted upon, while in the sprint test the entire body mass was being moved; perhaps this much mass did not allow for maximal power production in the short intervals in which it was measured. Also, significant power was generated but not measured during the sprint test at the start and end of each sprint. This change of direction is similar to the activities of many athletes in competition that is not a part of the WAT. With this in mind, while WAT peak power ratings were technically higher, they may be misleading if used to evaluate power in running-based athletes.

The possible $[La]_b$ difference was plausibly due to the greater amount of muscle activation in sprint running as compared to cycle ergometry. The additional active muscle mass may have created a significantly higher amount of lactate. The reviewed literature provided slightly higher $[La]_b$ than found in this study. Sands et al reported a $[La]_b$ of slightly more than 15 mmol/L for males on the WAT in their study, however his participants were NCAA Div.- I track and field athletes. Hirvonen et al reported $[La]_b$ of 14.9 mmol/L in sprint trained males running 200-m sprints, which appears to be comparable to Sands et al's findings. Lacour et al's findings provided the highest $[La]_b$ found, with 20.1, 21.9, and 20.8 mmol/L generated by world-class male runners running distances of 400-m, 800-m, and 1500-m respectively.

While this study only found significant correlations between mean power across tests, other studies have found significant correlations between similar parameters. Tharp, et al found significant correlations between the 50-yard and 600-yard run times observed in their study and WAT mean power, as did Patton & Duggan in their study using 50- and 200-m sprints. The most similarity between the current study and the literature reviewed exists with the study by Hoffman, et al.

The line drill is a continuous 143.4-m sprint, while the total sprint distance in this study was 146.3 m. Hoffman, et al found a significant correlation between line drill time and mean power, while the current study found a significant correlation between mean power calculated from the two tests. The current study's lack of other significant correlations may have been due to the low number of subjects.

There seems to be some initial agreement between the four 40-yard sprint test and published literature, however the small sample prevents usable correlations from being calculated. Agreement seems to lie in mean power findings with the different studies.

In conclusion, the proposed sprint test is possibly a good indicator of mean anaerobic power, but seems to be a poor test for peak anaerobic power. These conclusions are only of limited usefulness due to the statistical problems imposed by a limited sample size. A similar study with a larger sample size is necessary to confirm and clarify the results provided in this study. Research is also needed using females and athletes for generalizability to those populations.

## REFERENCES


1. Bar-Or O. (1987). The Wingate Anaerobic Test. An update on methodology, reliability, and validity. *Sports Med*, 4(6), 381-94.

2. Dolny DG, Collins MG, Germann SL, Phipps WT, Davis HR. (2000). Comparison of power output generated on the Wingate cycle ergometer and on a new, closed-chain lower-extremity dynamometer. *J Strength Cond Res*, 14(1), 87-91.

3. Dudka J, Burdan F, Korobowicz A, Klepacz R, Korobowicz E. (2004). Human skeletal muscle lactate dehydrogenase activity in the presence of some alcohol dehydrogenase inhibitors. *Basic Clin Pharmacol Toxicol*, 95(1), 38-42.

4. Gratas-Delamarche A, Le Cam R, Delamarche P, Monnier M, Koubi H. (1994). Lactate and catecholamine responses in male and female sprinters during a Wingate test. *Eur J Appl Physiol Occup Physiol*, 68(4), 362-6.

5. Hirvonen J, Nummela A, Rusko H, Rehunen S, Harkonen M. (1992). Fatigue and changes of ATP, creatine phosphate, and lactate during the 400-m sprint. *Can J Sport Sci*, 17(2), 141-144.

6. Hoffman JR, Epstein S, Einbinder M, Weinstein Y. (2000). A comparison between the Wingate Anaerobic Power Test to both vertical jump and line drill tests in basketball players. *J Strength Cond Res*, 14(3), 261-4.

7. Lacour JR, Bouvat E, Barthelemy JC. (1990). Post-competition blood lactate concentrations as indicators of anaerobic energy expenditure during 400-m and 800-m races. *Eur J Appl Physiol Occup Physiol*, 61, 172-6.

8. Moir G, Button C, Glaister M, Stone MH. (2004). Influence of familiarisation on reliability of the vertical jump and acceleration sprinting performance in physically active men. *J Strength Cond Res*, 18(2), 276-280.

9. Patton JF, Duggan A. (1987). An evaluation of tests of anaerobic power. *Aviat Space Envir Med*, 58, 237-42.

10. Sands WA, McNeal JR, Ochi MT, Urbanek TL, Jemni M, Stone MH. (2004). Comparison of the Wingate and Bosco Anaerobic Tests. *J Strength Cond Res*, 18(4), 810-15.

11. Seiler S, Taylor M, Diana R, Layes J, Newton P, Brown B. (1990). Assessing anaerobic power in collegiate football players. *J Appl Sport Sci Res*, 4(1), 9-15.

12. Shiraishi K, Watanabe M, Motegi S, Nagaoka R, Matsuzaki S, Ikemoto H. (2003). Influence of acute alcohol load on metabolism of skeletal muscles-expired gas analysis during exercise. *Alcohol Clin Exp Res*, 27(8 Suppl), 76S-78S.

13. Tharp GD, Newhouse RK, Uffelman L, Thorland WG, Johnson GO. (1985). Comparison of sprint and run times with performance on the Wingate Anaerobic Test. *Res Q Exercise Sport*, 56(1), 73-6.

14. Thomas C, Plowman SA, Looney MA. (2002). Reliability and validity of theanaerobic speed test and the field anaerobic shuttle test for measuring anaerobic work capacity in soccer players. *Meas Phys Act Exerc Sci*, 6(3), 187-205.

# APPENDIX A

## LIMITATIONS AND DELIMITATIONS

The greatest limitations of this study are the small sample size as well as a non-random sample. For the tests performed, 15 participants do not provide adequate statistical power to make the assertions that these results suggest. In addition to these, some experimental mortality was experienced, further reducing the usable sample size. Finally, generalizability of these results to athletes and females is compromised due to the study population.

Delimitations include the use of only male test subjects. This is due to evidence of gender-specific lactate responses on the WAT (Gratas-Delamarche, et al). To include females would necessarily double the size of the study. Due to the cost of research supplies, specifically the strips used with the Nova Lactate Plus device, doubling the size of the study would have been financially infeasible. Although this test was proposed for eventual use in athletic populations, athletes were excluded to eliminate the need to coordinate testing with coaches' and players' training and competition schedules.

APPENDIX B

ABBREVIATIONS AND DEFINITIONS

**$[La]_b$**-- Blood lactate concentration; is an indicator of energy production via anaerobic pathways, and has been used to estimate total anaerobic energy production

**mmol/L**-- millimoles per Liter; the standard unit of measure in which $[La]_b$ is expressed

**MP**-- Mean Power; the average amount of power generated during a test expressed in Watts

**PP**-- Peak Power; the highest amount of power generated in a single interval of an anaerobic test, expressed in Watts

**RPE**-- Rating of perceived exertion; a measure of physical exertion subjectively reported by a testing participant

**WAT**-- Wingate Anaerobic Test; a widely accepted cycle-ergometer based test of anaerobic parameters

## APPENDIX C

## INFORMED CONSENT

1. My name is Chris Johnson and I am a graduate student here at Georgia Southern University. I am carrying out this study to complete degree requirements for a M.S. Kinesiology/Exercise Science.

2. The purpose of this research is to help support validity for a four 40-yard sprint test as a test of anaerobic capacity. The sprint test will be validated against the Wingate test, which is the accepted laboratory test for anaerobic capacity.

3. Participation in this study will involve completing two tests of anaerobic capacity and having your finger pricked after each test to assess the concentration of lactate in your blood.

4. There are risks of discomfort and injury involved with this study. It is not believed that the tests involved will cause harm or great physical discomfort, nor are they intended to do so. The tests of anaerobic capacity are physically taxing. Participation in them poses a risk of musculoskeletal injury. It is also impossible to exclude the possibility of death due to cardiovascular problems. The risk of all of these injuries is very small, and the primary and secondary researchers are American Red Cross certified to provide First Aid, as well as CPR/AED certified. Please understand that medical care is available in the event of injury resulting from research but that neither financial compensation nor free medical treatment is provided. Also understand that you are not waiving any rights that you may have against the University for injury resulting from negligence of the University or investigators. In the event of an injury during testing, you should immediately report it to a researcher. Those who wish to seek assistance following the study may contact Chris Johnson (404-895-1532), Health Services (912-681- 5641), or the Counseling Center (912-681-5541).

5. Benefits:
   a. The benefits to participants include the ability to participate in scientific research and assist in the accumulation of scientific knowledge.
   b. The benefits to society include the possible development of a valid and simple field test for anaerobic capacity that can be executed with a minimum of equipment and personnel.

6. Duration/Time: Approximately 30 minutes on 2 separate days at least 48 hours apart.

7. Statement of Confidentiality: All of the personal information collected on each participant will be kept confidential by the researchers. All results and data analysis will be reported by randomly assigned participant numbers. Only the primary researcher and the advising professor have access to the list of names and participant numbers.

8. Right to Ask Questions: Participants have the right to ask questions and have those questions answered. If you have questions about this study, please contact the researcher named above or the researcher's faculty advisor, whose contact information is located at the end of the informed consent. For questions concerning your rights as a research participant or the IRB approval process, contact Georgia Southern University Office of Research Services and Sponsored Programs at 912-681-0843.

9. Compensation: There will be no monetary compensation for participation in this study.

10. Voluntary Participation: Participation in this study is completely voluntary. Participants have the right at any time to defer a testing phase to a later date or to withdraw from the study altogether.

11. Penalty: There is no penalty for choosing to not participate in this study after reading this Informed Consent. There is also no penalty or retribution associated with deferring a testing phase or withdrawing completely from the study at any time for any reason.

12. This study does not involve any deception of testing participants.

13. You must be 18 years of age or older to consent to participate in this research study. If you consent to participate in this research study and to the terms above, please sign your name and indicate the date below.

You will be given a copy of this consent form to keep for your records.

Title of Project:
Validation of a four 40-yard sprint test for anaerobic capacity vs. the Wingate Anaerobic Test

Principal Investigator:
Peter Christian Johnson
18 East Olliff St., Apt. 4
Statesboro, GA 30458
(404) 895-1532; JohnsonPC05@gmail.com

Other Investigator(s):
Tom Melton

Georgia Southern University
PO Box 8084
Statesboro, GA 30460
(912) 681-0296; tmelton@georgiasouthern.edu

Matt Lombardi
Georgia Southern University
PO Box 8084
Statesboro, GA 30460
(912) 681-5965; mlombardi81@yahoo.com

Faculty Advisor:
Jim McMillan, Ed.D.
Department of Health and Kinesiology
P.O. Box 8076
Statesboro, GA 30460-8076
Voice: 912-871-1926
Email: jmcmillan@georgiasouthern.edu

_______________________________________ ________________________
Participant Signature Date

I, the undersigned, verify that the above informed consent procedure has been followed.

_______________________________________ ________________________

Investigator Signature Date

APPENDIX D

PARTICIPANT STATEMENT OF WILLINGNESS AND ABILITY TO PARTICIPATE IN TESTNIG

By signing this statement, I certify that I am willingly taking part in the four 40-yard sprint test phase, Wingate test phase (circle appropriate) today, and that I know of no reason why I should be unable to perform the testing or that data obtained from my performance would be unusable. Reasons that may prevent willingness or ability to test may include, but are not limited to: existing musculoskeletal injury or pain, fatigue, alcohol intoxication in the previous 48 hours, illness or fever, or malaise. I realize that there is no penalty or retribution for choosing to reschedule testing, or for withdrawing from the study altogether.

______________________
Participant signature

______________________ ____________________
Participant's Printed Name Date

# APPENDIX E

## STANDARD WARM-UP FOR THE SPRINT TEST

1. Flamencos  x2
2. Frankensteins  x2
3. Lunge Walk w/Twist  x2
4. Alternating Squats  x2
5. Knee Tuck Walk  x2
6. Walking Quad Stretch  x2
7. High Knees  x1
8. Butt Kicks  x1
9. Practice 40 @ ¾ speed, walk back

10 yd. of each exercise = 1 rep.

# APPENDIX F

## PRE-TESTING GUIDELINES

1. Please minimize alcohol consumption for 24 hrs. prior to each testing phase.
2. Please consume only water for 2 hrs. prior to each testing phase.
3. Wear comfortable athletic clothing that does not restrict movement to each testing phase.
4. Wear close-toed, close-heeled athletic shoes to each testing phase.