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14. ABSTRACT
The Wingate Anaerobic Test (WAnT) has been established as an effective tool in measuring both muscular power and anaerobic capacity in a 30-second time period; however there are no published normative tables by which to compare WAnT performance in male and female collegiate athletics. The purpose of this study was to develop a classification system for anaerobic peak power and anaerobic capacity for male and female NCAA Division I college athletes using the WAnT. One thousand three hundred and seventy four male and 211 female tests were conducted on athletes ranging from the ages of 18 to 25 using the WAnT. Absolute and relative peak power and anaerobic capacity data were recorded. One-half standard deviations were used to set up a seven-tier classification system (poor to elite) for these assessments. These classifications can be used by athletes, coaches, and practitioners to evaluate anaerobic peak power and anaerobic capacity in their athletes.

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Wingate Anaerobic Test Peak Power and Anaerobic Capacity Classifications for Men and Women Intercollegiate Athletes

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Abstract

Zupan, MF, Arata, AW, Dawson, LH, Wile, AL, Payn, TL, and Hannon, ME. Wingate Anaerobic Test peak power and anaerobic capacity classifications for men and women intercollegiate athletes. *J Strength Cond Res* 23(9): 2598–2604, 2009–The Wingate Anaerobic Test (WAnT) has been established as an effective tool in measuring both muscular power and anaerobic capacity in a 30-second time period; however, there are no published normative tables by which to compare WAnT performance in men and women intercollegiate athletics. The purpose of this study was to develop a classification system for anaerobic peak power and anaerobic capacity for men and women National Collegiate Athletic Association (NCAA) Division I college athletes using the WAnT. A total of 1,585 (1,374 men and 211 women) tests were conducted on athletes ranging from the ages of 18 to 25 years using the WAnT. Absolute and relative peak power and anaerobic capacity data were recorded. One-half standard deviations were used to set up a 7-tier classification system (poor to elite) for these assessments. These classifications can be used by athletes, coaches, and practitioners to evaluate anaerobic peak power and anaerobic capacity in their athletes.

Key Words muscular power, fatigue index, absolute power, relative power, physical fitness

Introduction

Physical fitness can be assessed through 5 major components: cardiorespiratory endurance, muscular power/strength, muscular endurance, flexibility, and body composition. An anaerobic activity is defined as energy expenditure that uses anaerobic metabolism (without the use of oxygen) that lasts less than 90 seconds, utilizing an exhaustive effort (25). Two major energy sources are required during the WAnT. The first is the adenosine triphosphate-phosphocreatine (ATP-PCr) system, which lasts for 3 to 15 seconds during maximum effort (25). The second system is anaerobic glycolysis, which can be sustained for the remainder of the all-out effort (25). Therefore, the WAnT measures the muscles' ability to work using both the ATP-PCr and glycolytic systems. Many sports–including football, sprinting, soccer, baseball, lacrosse, and gymnastics–use anaerobic metabolism extensively during competition. This study examines the aspect of lower-body peak power and anaerobic capacity using the 30-second exhaustive Wingate Anaerobic Test (WAnT).

Several tests can assess an athlete's peak power (a measure of muscular strength and speed), anaerobic capacity, or both. These tests include the vertical jump test, standing long jump test, Bosco repeated jumps (18), and WAnT (3,6,11).

The WAnT measures lower-body peak power; anaerobic capacity; and the reduction of power, known as fatigue index (FI) (3,7). The WAnT is a 30-second all-out exhaustive ergometry test where the athlete pedals against a resistance that is set at a certain percentage of his or her body weight. The power output is measured throughout the test by the number of revolutions the athlete can achieve on the ergometer during those 30 seconds. The peak power recorded is the maximal power output achieved for 5 seconds of the test, usually the first 5 seconds. The anaerobic capacity, or average power, is recorded and averaged over the entire 30 seconds of the test. The lowest power output is an average of the lowest 5 seconds seen during the test, usually the last 5 seconds. Finally, the difference in power output from highest to lowest is recorded as the FI. The ability to evaluate these

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measurements makes the WAnT a valuable test for coaches, athletes, and research scientists.

Many researchers and coaches measure muscular strength with a 1-repetition maximum (1RM) lift (11). They also measure muscular endurance via repetition lifts (to include bench press at a percent of the athlete's body weight, push-ups, sit-ups, or pull-ups) until exhaustion. These measurements allow a coach to observe individual improvements; however, it is difficult to truly compare one athlete's data to another's in a lifting exercise unless the exact distance of the lift or weight (in the case of push-ups or pull-ups) is equal. Comparing an athlete's data to a set standard is important for athletes and coaches of sports that require both muscular power and anaerobic capacity. Until this study, there has not been a compilation of data to compute normative tables by which athletes could compare their Wingate scores.

Table 1. Demographic characteristics of the participants (mean ± *SD*).

	Men (*n* = 457)	Women (*n* = 64)
Age (years)	19.7 ± 1.6	19.3 ± 1.3
Weight (kg)	81.2 ± 11.8	62.1 ± 7.7
Height (cm)	180.6 ± 7.8	167.1 ± 7.9
Sports tested	Lacrosse, football, water polo, boxing, track, cycling, soccer, baseball, and wrestling	Tennis, track, soccer, and gymnastics

Methods

Experimental Approach to the Problem

The purpose of this study was to develop a classification system for anaerobic peak power and anaerobic capacity for men and women college-age athletic populations.

Subjects

National Collegiate Athletic Association (NCAA) Division I athletes from the U.S. Air Force Academy between the ages of 18 and 25 years participated in this study (Table 1). The athletes came from sports that require short bursts of peak power and a high anaerobic capacity during competition to include lacrosse, gymnastics, sprint cycling, football, baseball, tennis, and track. A total of 1,585 WAnTs (1,374 men and 211 women) were administered to 521 Division I athletes (457 men, 64 women). These data were preexisting data from the quarterly, semi-annual, or annual testing that these teams perform for training purposes; thus no informed consent documents (ICDs) were obtained.

Procedures

Prior to testing, body weight was collected using a Detecto electronic scale. The athletes were then fitted for their optimal seat height on a Monark 824E or 874E weight ergometer. These ergometers were specially designed WAnT ergometers, with instantaneous load and braking systems. The seat height was adjusted so that no more than 5 degrees of knee flexion was present when the leg was fully extended. Each subject was then given a 3 to 5 minute warm-up period on a Monark 868 cycle ergometer, striving to achieve a warm-up heart rate of 130 to 140 beats per minutes (bpm). Athletes who had not previously taken the WAnT were required to perform 2 or 3, 5-second high revolution spins during their warm-up. This was completed to acquaint the athletes with the pedaling speed requirements of the WAnT.

The resistance load was set at 7.5% of the subject's body weight within a 0.1-kg resolution of resistance range. This load was used for tests in both men and women. Prior to getting on the ergometer for the test, a Polar Vantage NV heart rate monitor transmitter was placed around the athletes'

Table 2. Wingate test results.

	PP (W)	PP (W/kg^{-1})	AC (W)	AC (W/kg^{-1})	FI (%)	HR (bpm)
Men (*n* = 457)						
Mean	951	11.65	686	8.47	47	183
SD	141	1.39	91	0.88	7.6	14
Range	448–1,529	6.12–17.27	231–983	4.80–11.45	13–77	138–227
Women (*n* = 64)						
Mean	598	9.59	445	7.16	42	180
SD	88	0.99	64	0.70	7.9	9
Range	388–822	6.10–12.30	288–651	5.00–8.93	16–61	154–208

PP = peak power; AC = anaerobic capacity; FI = fatigue index; HR = heart rate; bpm = beats per minute.

TABLE 3. Wingate Anaerobic Test power comparisons for men.

Author	Year	Sample size (*n*)	Subject type	Peak power (W)	Relative peak power (W/kg^{-1})	Average power (W)	Average power (W/kg^{-1})
Current study	2008	1,374	18–25-year-old intercollegiate athletes	951	11.65	686	8.47
Al-Hazzaa et al. (1)	2001	23	25-year-old elite soccer players	873	11.88	587	8.02
Apostolidis et al. (2)	2004	13	Junior Basketball League (age: 18.5 years)	–	10.70	–	8.00
Barfield et al. (4)	2002	25	20 years old	868		634	
Bell and Cobner (5)	2007	41	21-year-old rugby players	1,154			
Heller et al. (9)	1998	11	Tae kwon do national team		14.70		
Kocak and Karli	2003	20	International-level wrestlers		10.52		8.12
Mangine et al. (13)	1990	83	National soccer players	538	8.10		
Maud and Shultz	1989	60	18–28 years old	700	9.18	563	7.28
Nindl et al. (15)	1995	20	High school athletes	694	9.10	548	7.20
Patton et al.	1985	10	Olympic biathletes		11.25		9.21
Peveler et al.	2007	9	Trained cyclists	1,248		648	
Ponorac et al. (17)	2007	95	Judo			798	9.64
			Soccer			763	9.75
			Rowers			691	8.84
			Nonathletes			557	6.93
Sbriccoli et al.	2007	6	Olympic-level jodokas	1,236	12.10	557	5.40
Starling et al. (20)	1996	10	Competitive cyclists		8.50		
Watson and Sargeant (22)	1986	24	University hockey players (age = 20 years)		10.10		7.70
Weber et al. (23)	2006	10	Active males	1,055	13.30	766	9.70
Wiegman et al. (24)	1995	10	25-year-old athletes	850	10.35	620	7.55

Table 4. Wingate Anaerobic Test power comparisons for women.

Author	Year	Sample size (n)	Subject type	Peak power (W)	Relative peak power (W/kg^{-1})	Average power (W)	Average power (W/kg^{-1})
Current study	2008	211	18–25-year-old intercollegiate athletes	598	9.59	445	7.16
Findley et al. (8)	2002	10	Female firefighters	451	–	314	–
Heller et al.	1998	12	Tae kwon do national team	–	10.10	–	–
Jacob et al. (10)	2002	19	7 endurance trained (ET)	508	9.50	409	7.70
			6 sprinters (ST)	710	12.60	510	9.00
Maud and Shultz	1989	60	18–28 years old	454	7.61	380	6.35
Nindl et al.	1995	20	High school athletes	442	7.50	307	5.30
Sbriccoli et al. (19)	2007	5	Olympic-level jodokas	635	9.50	285	4.30
Thorland et al. (21)	1986	31	Junior-level sprint/mid-distance runners	418	9.10		
Weber et al.	2006	10	Active female	725	11.40	518	8.10
Woolstenhulme et al. (26)	2004	18	Division I basketball players	–	–	–	6.60

Table 5. Wingate Anaerobic Test classification of peak power (W, W/kg^{-1}) and anaerobic capacity (W, W/kg^{-1}) for men.

Categories	Peak power (W)	Peak power (W/kg^{-1})	Anaerobic capacity (W)	Anaerobic capacity (W/kg^{-1})
Elite	>1,163	>13.74	>823	>9.79
Excellent	1,092–1,163	13.04–13.74	778–823	9.35–9.79
Above average	1,021–1,091	12.35–13.03	732–777	8.91–9.34
Average	880–1,020	11.65–12.34	640–731	8.02–8.90
Below average	809–879	10.96–11.64	595–639	7.58–8.01
Fair	739–808	9.57–10.95	549–594	7.14–7.57
Poor	<739	<9.57	<549	<7.14

Table 6. Wingate Anaerobic Test classification of peak power (W, W/kg^{-1}) and anaerobic capacity (W, W/kg^{-1}) for women.

Categories	Peak power (W)	Peak Power (W/kg^{-1})	Anaerobic capacity (W)	Anaerobic capacity (W/kg^{-1})
Elite	>730	>11.07	>541	>8.22
Excellent	686–730	10.58–11.07	510–541	7.86–8.22
Above average	642–685	10.08–10.57	478–509	7.51–7.85
Average	554–641	9.10–10.07	414–477	6.81–7.50
Below average	510–553	8.60–9.09	382–413	6.45–6.80
Fair	467–509	8.11–8.59	351–381	6.10–6.44
Poor	<467	<8.11	<351	<6.10

chests to allow for heart rate monitoring during warm-up, the 30-second test, and recovery. Heart rate measurements were used during active recovery as the athletes pedaled until their heart rates' returned to approximately 120 bpm.

The actual testing procedure consisted of the athletes performing a 10-second countdown phase, a 30-second all-out pedaling phase, and an active recovery phase. During the first 5 seconds of the countdown the athletes began pedaling at a comfortable cadence and became situated on the ergometer. Five seconds prior to the start of the test, the athletes began to pedal at their maximum speed against a resistance approximately one third of their testing intensity. With less than 1 second left in the countdown, resistance was added instantaneously by dropping the weight rack. The Monark weight ergometers have a pin that is pulled (824E) or a lever (874E) that allows for instantaneous weight loading. Data were then recorded for the next 30 seconds using an SMI OptoSensor 2000 and the Wingate Power software program. This system is similar to the testing device described by Patton et al. (16) in which an automatic computerized counter was used to tally the total number of revolutions completed during the 30-second test.

All subjects were verbally encouraged to continue to pedal as fast as they could for the entire 30 seconds. Peak power and anaerobic capacity were calculated and recorded in watts (W) and watts per kilogram body weight (W/kg^{-1}); the FI was calculated as a percentage, and heart rates were recorded in bpm. Classification categories were created for both women and men athletes based on their peak power and anaerobic capacity scores.

Results

Peak power and anaerobic capacity in absolute (W) and relative to body weight (W/kg^{-1}) were determined for the WAnT. The data were analyzed and classified using descriptive statistics (Table 2).

A 7-bin category structure was formed from the data collected. Each component was broken down into averages ± standard deviation using EXCEL descriptive statistics. The categories were then constructed from a ±0.5 standard deviation change. These categories consist of elite, excellent, above average, average, below average, fair, and poor.

Discussion

Success in many sports requires high leg power and anaerobic capacities. Some sports require absolute power, or the highest power output possible, independent of body size, such as football linemen, power lifters, or hammer throwers. If 2 players' skill level or technique are equal, then the more powerful athlete will usually outperform the less powerful opponent. Other sports, where the athlete must move his or her body across a field or ice rink with a quick burst of energy, require a high relative peak power and anaerobic capacity. Up until now, WAnT studies with a large sample size have not been completed on well-trained college-age athletes and thus there has been no classification system developed for coaches to interpret test results. The purpose of this study was to develop a classification system for absolute and relative peak power and anaerobic capacity for men and women college-age athletic populations. In doing this, any athlete can perform the WAnT and compare themselves to other athletes on a scale from "poor" to "elite."

Our data closely reflect the data on various research projects with small sample sizes. Studies investigating power or training effects related to power are summarized for men (Table 3) and women (Table 4). These tables reflect the peak power and anaerobic capacities reported and are compared to the means of this study. When comparing the data, it is important to recognize the differing subject samples. Studies that used college-age elite athletes are most comparable to the present study (1,2,12), whereas older and younger subject studies, and studies completed on standard 868 ergometers, may not be as relevant. Before 1999 the automatic weight basket system had not been used extensively in most human performance laboratories. All but a few labs had to manually crank the load adjustment knob to quickly add the load. With this in mind, the delay time to reach maximum resistance was most likely 2 to 4 seconds, reducing the peak power and possibly the anaerobic capacity because the 30 seconds usually did not start until the final load was reached. Today's ergometers allow for instantaneous loading and recording so the athlete receives credit for the initial seconds of the test. Most studies performed prior to 1999, with the exception of 1 (16), report substantially lower peak power and anaerobic capacities than the present study.

The study performed by Maud and Shultz (14) is the only other known study that has attempted to set normative tables by which to compare WAnT performance. This study consisted of 186 subjects (112 men and 74 women) from club and varsity sports, physical education majors, and physical education students. They established a percentile ranking in men and women for peak power (W, W/kKg^{-1} and $W/kgLBM^{-1}$), mean power (W, W/kg^{-1} and $W/kgLBM^{-1}$), and fatigue index (%). Testing for this study was performed with manual counting on a standard 818 ergometer and may have resulted in human error at the higher revolutions. The authors also reported a 2- to 3-second delay in reaching the required load (14); thus the athletes were working at maximal effort without receiving credit for this work. These 2 limitations, along with the fact that our subjects were all intercollegiate athletes, may account for the significantly higher averages in all WAnT categories seen in this study.

A 7-bin category structure was formed from the data collected. Tables 5 (men) and 6 (women) contain the category tier of peak power and anaerobic capacity (W and W/kg^{-1}) for intercollegiate athletes.

It is common to find 5 categories of evaluation to categorize many different levels of fitness for the average person (14). Most times these are simply broken up into percentiles, 0 to 20% being the lowest and so on. Sometimes 6 categories have been used. It was decided in this study to use a one half standard deviation to differentiate the categories and, in doing so, have 3 categories on either side of average. This 7-category system allows for a more accurate evaluation of the individual athlete and provides the clinician, coach, and athlete with a better understanding of the interpretation of the test results.

No classification system was set up for fatigue index or heart rates. The athletes were asked to bring their heart rates up to around 140 bpm during warm-up and to perform an active recovery following the WAnT until their heart rates returned close to 120 bpm. It was found that the FI was inversely related to peak power. Having a high or low FI does not directly indicate an athlete's ability, but if there are 2 equally powerful athletes and 1 has a lower FI, then, physiologically speaking, that athlete will probably be the better athlete on the field. By itself, however, no value was found in setting up a classification system for the FI.

Practical Applications

The purpose of this study was to establish set standards for intercollegiate athletes in lower-body peak power and anaerobic capacities from the Wingate Anaerobic Test. Although there have been multiple studies done involving the WAnT, none have been able to work with such a high number of well-trained athletes. The classification categories formulated will allow coaches, clinicians, and athletes to use these charts as tools to evaluate power output and provide comparisons from a set of reliable standards. This information should begin to create a framework by which athletes can compare their performance on the Wingate Anaerobic Test.

References

1. Al-Hazzaa, HM, Almuzaini, KS, Al-Refaee, SA, Sulaiman, MA, Dafterdar, MY, Al-Ghamedi, A, and Al-Khuraiji, KN. Aerobic and anaerobic power characteristics of Saudi elite soccer players. *J Sport Med Phys Fit* 41: 54–61, 2001.
2. Apostolidis, N, Nassis, GP, Bolatoglou, T, and Geladas, ND. Physiological and technical characteristics of elite young basketball players. *J Sport Med Phys Fit* 44: 157–163, 2004.
3. Bar-Or, O. The Wingate Anaerobic Test: An update on methodology, reliability, and validity. *Sports Med* 4: 381–394, 1987.
4. Barfield, J, Sells, PD, Rowe, DA, and Hannigan-Downs, K. Practice effect of the Wingate Anaerobic Test. *J Strength Cond Res* 16: 472–473, 2002.
5. Bell, W and Cobner, DM. Effect of individual time to peak power output on the expression of peak power output in the 30-s Wingate Anaerobic Test. *Int J Sports Med* 28: 135–139, 2007.
6. Chromiak, JA, Smedley, B, Carpenter, W, Brown, R, Koh, YS, Lamberth, JG, Joe, LA, Abadie, BR, and Altorfer, G. Effect of 10-week strength training program and recovery drink on body composition, muscular strength and endurance, and anaerobic power and capacity. *Nutrition* 20: 420–427, 2004.
7. Cooper, SM, Baker, JS, Eaton, ZE, and Matthews, N. A simple multistage field test for the prediction of anaerobic capacity in female games players. *Brit J Sport Med* 38: 784–789, 2004.
8. Findley, BW, Brown, LE, and Whitehurst, M. Anaerobic power performance of incumbent female firefighters. *J Strength Cond Res* 16: 474–476, 2002.
9. Heller, J, Peric, T, Dlouha, R, Kohlikova, E, Melichna, J, and Novakova, H. Physiological profiles of male and female taekwon-do (ITF) black belts. *J Sports Sci* 16: 243–249, 1998.
10. Jacob, C, Zouhal, H, Vincent, S, Gratas-Delamarche, A, Berthon, PM, Bentue-Ferrer, D, and Delamarche, P. Training status (endurance of sprint) and catecholamine response to the Wingate-test in women. *Int J Sports Med* 23: 342–347, 2002.
11. Jordan, AN, Jurca, R, Abraham, EH, Salikhova, A, Mann, JK, Morss, GM, Church, TS, Lucia, A, and Earnest, CP. Effects of oral ATP supplementation on anaerobic power and muscular strength *Med Sci Sports Exerc* 36: 983–990, 2004.
12. Kocak, S and Karli, U. Effects of high dose oral creatine supplementation on anaerobic capacity of elite wrestlers. *J Sports Med Phys Fitness* 43: 488–492, 2003.
13. Mangine, RE, Noyes, FR, Mullen, MP, and Barber, SD. A physiological profile of the elite soccer athlete. *J Orthop Sports Phys Ther* 12: 147–152, 1990.
14. Maud, PJ and Shultz, BB. Norms for the Wingate Anaerobic Test with comparison to another similar test. *Res Q Exerc Sport* 60: 144–151, 1989.
15. Nindl, BC, Mahar, MT, Harman, EA, and Patton, JF. Lower and upper body anaerobic performance in male and female adolescent athletes *Med Sci Sports Exerc* 27: 235–241, 1995.
16. Patton, JF, Murphy, MM, and Frederick, FA. Maximal power outputs during the Wingate Anaerobic Test. *Int J Sports Med* 6: 82–85, 1985.
17. Ponorac, N, Matavulj, A, Rajkovaca, Z, and Kavacevic, P. The assessment of anaerobic capacity in athletes of various sports. *Medicinski pregled* 60: 427–430, 2007.

18. Sands, WA, McNeal, JR, Ochi, MT, Urbanek, TL, Jemni, M, and Stone, MH. Comparison of the Wingate and Bosco Anaerobic Tests. *J Strength Cond Res* 18: 810–815, 2004.

19. Sbriccoli, P, Bazzucchi, I, Di Mario, A, Marzattinocci, G, and Felici, F. Assessment of maximal cardiorespiratory performance and muscle power in the Italian Olympic judoka. *J Strength Cond Res* 21: 738–744, 2007.

20. Starling, RD, Trappe, TA, Short, KR, Sheffield-Moore, M, Jozsi, AC, Fink, WJ, and Costill, DL. Effect of inosine supplementation on aerobic and anaerobic cycling performance. *Med Sci Sports Exerc* 28: 1193–1198, 1996.

21. Thorland, WG, Johnson, GO, Cisar, CJ, Housh, TJ, and Tharp, GD. Strength and aerobic responses of elite young female sprint and distance runners. *Med Sci Sports Exerc* 19: 56–61, 1987.

22. Watson, RC and Sargeant, TL. Laboratory and on-ice comparisons of anaerobic power of ice hockey players. *Can J Appl Sport Sci* 11: 218–224, 1986.

23. Weber, CL, Chia, M, and Inbar, O. Gender difference in anaerobic power of the arms and legs–a scaling issue. *Med Sci Sports Exerc* 28: 129–137, 2006.

24. Wiegman, JF, Burton, RR, and Forster, EM. The role of anaerobic power in human tolerance to simulated aerial combat maneuvers. *Aviat Space Environ Med* 66: 938–942, 1995.

25. Wilmore, JH and Costill, DL. *Physiology of sport and exercise (3rd edition)* Champaign, IL: Human Kinetics, 2004.

26. Woolstenhulme, MT, Bailey, BK, and Allsen, PE. Vertical jump, anaerobic power, and shooting accuracy are not altered six hours after strength training in collegiate women basketball players. *J Strength Cond Res* 18: 422–427, 2004.