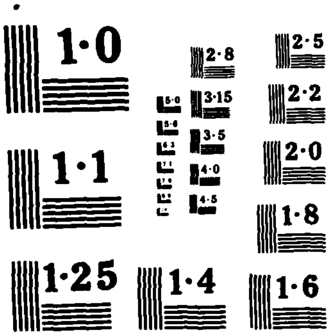
AD-A162 826 AN EVALUATION OF TESTS OF ANAEROBIC POWER(U) ARMY 1/1
RESEARCH INST OF ENVIRONMENTAL MEDICINE NATICK MA
J F PATTON ET AL. DEC 85 USARIEM-M7/86
UNCLASSIFIED F/G 6/16 NL

END
FILMED
DTIC



NATIONAL BUREAU OF STANDARDS
MICROCOPY RESOLUTION TEST CHART

(1)

AD-A162 826

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS
BEFORE COMPLETING FORM

1. REPORT NUMBER M7/86	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) An Evaluation of Tests of Anaerobic Power		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
. AUTHOR(s) John F. Patton and Andrew Duggan		8. CONTRACT OR GRANT NUMBER(s)
. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Research Institute of Environmental Medicine, Natick, MA 01760-5007		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
1. CONTROLLING OFFICE NAME AND ADDRESS US Army Research Institute of Environmental Medicine, Natick, MA 01760-5007		12. REPORT DATE December 1985 13. NUMBER OF PAGES 20
4. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution is unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

DTIC
ELECTE
DEC 30 1985
S D
A

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Anaerobic power, Wingate test, sprints, isokinetic endurance.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The objectives of this study were to examine the relationship between two laboratory tests of anaerobic power (AnP) and to compare these tests to field measures of AnP. Fifteen male subjects, aged 20-34 yrs, performed: 1) a 30s maximal cycle ergometer test (Wingate test, WT), 2) a 60s isokinetic knee extension test (isokinetic endurance test, IET), 3) a 50m sprint, 4) a 200m sprint, and 5) the Margaria stairclimb test. Significant correlations ranging from 0.52 to 0.76 were found between the WT and IET for peak and mean values of power and torque, respectively. Indices from both these tests also correlated

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

DTIC FILE COPY

HUMAN RESEARCH

Human subjects participated in these studies after giving their free and informed voluntary consent. Investigators adhered to AR 70-25 and USAMRDC Regulation 70-25 on Use of Volunteers in Research.

The views, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other official documentation.

An Evaluation of Tests
of Anaerobic Power

by

John F. Patton and Andrew Duggan

Army Personnel Research Establishment,
c/o RAE, Farnborough, Hants
United Kingdom

Running Head: Anaerobic power tests

Address for Correspondence:
John F. Patton
USARIEM
Natick, MA 01760
(617) 651-4840

1-A

ABSTRACT

The objectives of this study were to examine the relationship between two laboratory tests of anaerobic power (AnP) and to compare these tests to field measures of AnP. Fifteen ~~male subjects~~ soldiers, aged 20-34 yrs, performed: 1) a 30s maximal cycle ergometer test (Wingate test, WT); 2) a 60s isokinetic knee extension test (isokinetic endurance test, IET); 3) a 50m sprint; 4) a 200m sprint; and 5) the Margaria stairclimb test. Significant correlations ranging from 0.52 to 0.76 were found between the WT and IET for peak and mean values of power and torque, respectively. Indices from both these tests also correlated significantly with the field tests of AnP. The best single index was mean power from the WT which had correlations of -0.79, -0.82, and 0.74 with the 50m and 200m sprint times and the Margaria test, respectively. The data suggest that both the WT and IET represent valid laboratory tests for evaluating high-intensity short-term exercise in which the muscle is primarily dependent upon anaerobic processes for energy release.

Index Terms: anaerobic power, Wingate test, sprints, isokinetic endurance.

Introduction

The ability to sustain muscular activity which involves repetitive contractions of large muscle groups is inversely related to the force of the contractions employed. Exercise intensities where muscular contractions amount to 15-25 percent of maximal voluntary contraction may be maintained for extended periods of time and are dependent on the availability of oxygen as a source of energy. A person's capacity for high-intensity, short-term exercise where the force generated by repeated muscular contractions is greater than 50 percent of maximal voluntary contraction is, for the most part, dependent upon anaerobic processes for energy release. Such processes have been fairly extensively studied but chiefly in terms of oxygen debt mechanisms (11,12). The rate of anaerobic energy release has also been studied by assessing the appearance of lactate in the blood but not in terms of fatigue or exhaustion and, thus, capacity for anaerobic metabolism (14).

The capacity of the human for anaerobic exercise constitutes an important component of physical exercise with great practical implications. Until recently, the assessment of anaerobic capacity has been given little attention by the scientific community. A list of typical anaerobic activities would include sprinting up a steep incline, walking or running with a heavy load and heavy repetitive lifting. The daily activity schedule of a combat soldier, therefore, involves many bouts of high-intensity anaerobic physical exercise.

The development of procedures for measuring the ability of human muscle to generate power during high-intensity exercise has received considerable attention in recent years. Such procedures have ranged from simple field tests such as sprinting (15) to laboratory techniques comprising various modes of exercise, eg. treadmill running (4,20), stairclimbing (13), vertical jumping (3), isokinetic knee extension (24), and cycle pedalling (1,16,21). While no single test has gained the popularity equivalent to the determination of $\dot{V}O_2$max as a measure of aerobic power, two laboratory performance tests, the Wingate cycle ergometer test and isokinetic endurance test, have received considerable interest as measures of anaerobic power (1,7,9,19,24,25). The purposes of this study, therefore, were to compare data obtained from the Wingate test to that from the isokinetic endurance test and to compare these two tests to field measures of anaerobic power.

METHODS

Fourteen APRE trials section soldiers, 20-34 yrs old, participated in the study. Their physical characteristics were (mean ± SD): height 173.7 ± 6.7 cm, weight 76.5 ± 7.7 kg, percent body fat 16.7 ± 4.6%, $\dot{V}O_2$max 49.1 ± 5.1 ml/kg·min. The subjects reported to the laboratory at the same time each day during a two week period. During the first week all subjects were familiarized with the testing procedures and then on separate days they performed either the Wingate test (WT) or the isokinetic endurance test (IET). In the second week all subjects underwent the field tests which comprised 50m and 200m timed sprints and the stairclimb test of Margaria et al, (13).

Height, weight and percent body fat were assessed for all subjects during the first week of testing. Body fat was determined from the sum of skinfold thicknesses at the subscapular, triceps, biceps and suprailiac sites using the equations of Durnin and Womersley (5).

The direct measurement of $\dot{V}O_2max$ was made within a one month period either before or after the present study and the data are presented herein to characterize the aerobic capacity of the subjects. A discontinuous treadmill protocol was used with oxygen uptake being measured by the Douglas bag technique (22).

The protocol for the WT involved leg pedalling at maximal velocity for 30s against a resistance determined according to the subjects body weight. The WT was performed on a Bodyguard 990 cycle ergometer modified to permit the instantaneous application of resistance. The weighted pendulum was replaced by a counter-balanced lever arm to which a weight is attached that can be moved to obtain the desired resistance. Pedal revolutions were measured with a photocell attached near the flywheel and were monitored using a recorder. The resistance applied was 4.41 joules/pedal revolution/kg body weight (BW). Prior to each test, subjects warmed up on a standard Bodyguard 990 ergometer for 2-4 minutes at an intensity of 75-125W. The seat height on the Wingate ergometer was adjusted for each subject and the feet were firmly strapped to the pedals. Subjects were instructed to attain a pedal rate of about 120 RPM and then to the command, "Ready, Go", they commenced to pedal as fast as possible against the ergometer's inertial resistance only. Upon reaching a maximal rate (within 1-2s) the lever arm was lowered applying resistance to the flywheel. At this same time the recorder was turned on and a stopwatch started for timing the test. Subjects were instructed to remain seated and were verbally encouraged to maintain maximal pedal rate throughout. At the end of 30s, the lever arm was lifted and the subject allowed to pedal at low resistance until sufficiently recovered. Power output (PO) was calculated each second of the test and then averaged over 5s periods. Three indices of anaerobic performance were then calculated: peak power (PP), the highest PO (watts) during any 5s period (usually the first 5s); mean power (MP), the average PO (watts) generated during the 30s; and power decrease (PD), the difference between PP and the lowest 5s PO expressed as percent decrease.

The protocol for the IET involved the movement of the lever arm of an isokinetic dynamometer (Cybex II) where the angular velocity is controlled at 180°/s by an internal resistance that accomodates to the muscular force applied. The IET was performed using knee extensors according to the procedure of Thorstensson (24). Subjects were instructed to perform 50 contractions with maximal effort and to resume the starting position passively after each contraction. On the leg extension IET, every contraction lasted 0.5s and the passive phase approximately 0.7s, ie the test lasted about 60s. The peak torque (Nm) of each contraction was measured and the following indices of torque were calculated: highest peak torque (HPT), the average peak torque of the first 5 contractions; mean peak torque (MPT), the average peak torque for the 50 contractions; and peak torque decrease (PTD), the percent decrease between HPT and the average peak torque of the final 5 contractions. To perform the leg extension IET, subjects were seated in a Cybex chair with the right leg attached to the lever arm of the dynamometer. Limb movement was isolated by means of straps across the chest, waist and thighs.

Anaerobic power was also measured using the stairclimb test of Margaria et al, (13). The protocol used consisted of a 6m run-up with the subject negotiating two stairs at a time. Switchmats were placed on the 6th and 12th steps and the time interval was measured to 0.001s using an electronic timer (Venner Electronics Ltd). Each subject was familiarised with sprinting up the stairs before making actual measurements. Five trials were performed and the mean of the three best was recorded as the subject's time. The height of each step was 0.165m for a total vertical lift of 0.99m. The external power output (watts) was computed as follows: vertical lift (m) x body weight (kg)/time(s).

Subjects performed the 50m and 200m sprints on separate days. All runs were conducted individually on a flat, tarmacked surface. The time was measured manually with a stopwatch.

RESULTS

The indices of anaerobic power calculated from the WT and IET as well as the mean data obtained from the sprints and Margaria test are shown in Table 1.

The correlation coefficients between indices of anaerobic power from the WT and those from the IET are presented in Table 2. Only correlations between corresponding absolute and relative values are shown. Each correlation coefficient was tested for a significant difference from zero. Significant correlation coefficients ranging from 0.52 to 0.76 were found among PO indices from the WT and corresponding peak torque values from the IET. The highest relationships were between MP (W/kg) and HPT (Nm/kg) and MP

(W/kg) and MPT (Nm/kg). There was no significant correlation between PD from the WT and PTD of the IET.

Correlation coefficients for the WT and IET and the field tests of anaerobic power are shown in Table 3. PP and MP (both on an absolute and relative basis) correlated significantly with the 50m sprint time and the Margaria test but were only significantly correlated with the 200m sprint time when expressed relative to BW. PD was not significantly correlated with any of the field tests. Similar relationships were also found between the indices of the IET and the field tests particularly for HPT. MPT failed to correlate with the 200m sprint time on either an absolute or relative basis. PTD was significantly correlated with 200m sprint time and the Margaria test expressed relative to BW. Expressing sprint performance as velocity rather than time had very little effect on the correlation coefficients with the WT and IET indices of anaerobic power apart from changing the sign. Figure 1 presents the individual data and regression equations for mean power from the WT and the two timed sprints.

DISCUSSION

The mean data obtained in this study are in general agreement with previously published values. The percent body fat and aerobic capacity of the subjects were similar to reports from other Army samples of comparable age (18,26). Power outputs measured from the Wingate test fell within the range of values previously reported (7,17,19). These studies have utilised subjects covering a wide range in aerobic and anaerobic capacities, activity levels, age and nationality. While there are few comparative data on peak torque values generated from the IET, the present results on knee extension agree quite well with those reported by Thorstensson et al (24) and those found in US infantry soldiers (17). The power output values from the Margaria test also fell within the range of values which have previously been published (10,18).

The significant positive correlations between indices of power output (WT) and peak torque (IET) support the findings of Inbar et al, (6) and Murphy et al, (17). These authors also reported that the highest relationships were between MP on the WT and HPT and MPT on the IET. The results support the hypothesis that the two tests are largely measuring the same physiological function of anaerobic power. However, at best only 50-60% of the variance can be explained by the results indicating that other factors are significantly involved. Differences in the muscle groups utilised during the exercise and the duration of the exercise could largely account for the remaining variance between these two tests. Further, it may be suspected that the difference in duration of the tests could account for the low correlation between the respective indices of fatigue, PD and PTD, which has also been reported by the above authors. Murphy et al (17), however, found that the correlation between PD and PTD was not improved when the latter was determined after only 20 to 25 contractions of the leg extensors (approximately 30 s). The reason for such a low correlation, therefore remains largely unexplained. However, the group tested herein was relatively homogeneous in terms of their aerobic and anaerobic capacity and in their state of physical training. Correlations between the two tests might be improved markedly by the inclusion of various athletic groups who presumably possess a wider range in muscle fibre types. Inbar et al (6) have shown that correlations between muscle fibre composition, expressed as percent fast twitch fibres and indices from both the WT (PP and PD) and the IET (HPT and PTD) were significant for trained subjects but not for those who were sedentary.

The significant correlations among indices of power output on the WT and field sprinting ability (both timed sprints and the Margaria test) were surprisingly high in view of the rather narrow ranges in performance times achieved by the subjects. The good relationships of the WT with the field measures indicate that the WT is a useful laboratory test of anaerobic power since the energy for muscular contraction in the performance of the sprints and Margaria test is largely derived from anaerobic sources. The present data on adult men agree with a previous report by Bar-Or and Inbar (2) who showed that PP and MP were good predictors of sprinting ability in 10-14 year old boys. Correlation coefficients ranging from 0.70 to 0.85 were found between these indices and running speeds in the 40 yard and 300 yard dashes. More recently, Kaczkowski et al (8) also reported a high correlation ($r = 0.91$) between PP and the 50m run time in young adult subjects. Correlations between PO indices and the sprints were markedly strengthened when the values were expressed relative to body weight. This finding is in agreement with the results of Tharp et al (23) who found that the WT became a stronger predictor of dash (50m) and run (600m) times in 10-15 yr old boys when results were adjusted for body weight. Among the PO indices calculated from the WT it would appear that MP (expressed relative to BW), based upon the high correlations seen with all three field tests, represents the best index to use in assessing anaerobic performance. This may reflect the fact that the time sequence is 30s in duration and thus both sources of anaerobic energy production, the phosphagen system and glycolysis, are being significantly taxed.

The significant correlations seen among the indices of peak torque from the IET and the field tests suggest that this test is also a reasonable measure of anaerobic power. In general, the correlations were not as good as those of the WT and only HPT correlated significantly with all three of the field tests. The lack of any correlation between MPT and the 200m sprint may reflect the difference in time between the two tests where MPT is calculated over approximately 60s and the 200m sprint averaged 29s. However, Inbar et al (6) also failed to show a significant correlation when MPT was compared against the 300m sprint.

In conclusion, the predominance of significant correlations between the laboratory and field tests suggests that the former are measuring some common aspects of anaerobic ability. However, differences in the relative strengths of the correlations indicate that each test may be measuring a slightly different component of the anaerobic spectrum. The best single index of anaerobic power is MP calculated from the WT expressed relative to body weight. This variable showed the highest correlations with peak torque indices from the IET as well as the field tests of anaerobic performance.

ACKNOWLEDGEMENTS

The authors wish to express their sincere appreciation to Emily Hamilton and Dora Ward for their excellent preparation of the manuscript.

This study was conducted while J.F. Patton served as a scientific exchange officer from the US Army Research Institute of Environmental Medicine, Natick, MA. 01760-5007, USA

REFERENCES

1. Bar-Or O. Le test anaerobic de Wingate. Symbioses 1981; 13:157-172.

2. Bar-Or O, Inbar O. Relationships among anaerobic capacity, sprint and middle distance running of school children. In: Shepard RJ and Lavalee H, eds. Physical fitness assessment - Principles, Practice and Application. Springfield: Charles C. Thomas, 1978:142-147.

3. Bosco C, Luhtanen P, Komi V. A simple method for measurement of mechanical power in jumping. Eur. J. Appl. Physiol 1983;50:273-282.

4. Cunningham DA, Faulkner JA. The effect of training on aerobic and anaerobic metabolism during a short exhaustive run. Med. Sci. Sports 1969;1:65-69.

5. Durnin JVGA, Womersley JW. Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men and women aged from 16-71 years. Brit. J. Nutr. 1974;32:77-92.

6. Inbar O, Kaiser P, Tesch P. Relationships between leg muscle fibre type distribution and leg exercise performance. Int. J. Sports Med. 1981;2:154-159.

7. Jacobs I. The effects of thermal dehydration on performance of the Wingate anaerobic test. Int. J. Sports Med. 1980;1:21-24,

8. Kaczkowski W, Montgomery DL, Taylor AW, Klissouras V. The relationship between muscle fibre composition and maximal anaerobic power and capacity. J. Sports Med. 1982;22:407-413.

9. Kaiser P, Rossner S, Karlsson J. Effects of B-adrenergic blockade on endurance and short-time performance in respect to individual muscle fibre composition. Int. J. Sports Med. 1981;2:37-42.

10. Kitigawa K, Suzuki M, Miyashita M. Anaerobic power output of young obese men: comparison with non-obese men and the role of excess fat. Eur. J. Appl. Physiol. 1980;43:229-234.

11. Knuttgen HG. Oxygen debt, lactate, pyruvate, and excess lactate following muscular work. J. Appl. Physiol. 1962;17:639-644.

12. Knuttgen HG. Oxygen debt after submaximal physical exercise. J. Appl. Physiol. 1970;29:651-657.

13. Margaria R,Aghemo P,Rovelli E. Measurement of muscular power (anaerobic) in man. J. Appl. Physiol. 1966;21:1662-1668.

14. Margaria R, Oliva R, di Prampero P, Cerretelli P. Energy utilization in intermittent exercise of supramaximal intensity. J. Appl. Physiol. 1969;26:752-760.

15. Matsudo V, Pena RA. Forty seconds run test: characteristics and application. Proc. World Congress Sports Med. 21st Brasilia 1978.

16. McCartney N, Heigenhauser GJF, Jones NL. Power output and fatigue of human muscle in maximal cycling exercise. J. Appl. Physiol. 1983;55:218-224.

17. Murphy MM, Knapik JJ, Vogel JA, Drews FR. Relationship of anaerobic power capacity to performance during a 5-day sustained combat scenario. USARIEM Tech Rpt T5/84, 1984.

18. Myles WS, Toft RJ. A cycle ergometer test of maximal aerobic power. Eur. J. Appl. Physiol. 1982;49:121-129.

19. Patton JF, Murphy MM, Fredericks FA. Maximal power outputs during the Wingate anaerobic test. Int. J. Sports Med. 1985;6:82-85.

20. Schnabel A, Kinderman W. Assessment of anaerobic capacity in runners. Eur. J. Appl. Physiol. 1983;52:42-46.

21. Szogy A, Cherebetiu G. A one-min bicycle ergometer test for determination of anaerobic capacity. Eur. J. Appl. Physiol. 1974;33:171-176.

22. Taylor HL, Buskirk E, Henschel A. Maximal oxygen uptake as an objective measure of cardiorespiratory performance. J. Appl. Physiol. 1955;8:73-80.

23. Tharp GD, Newhouse RK, Uffelman L, Thorland WG, Johnson GO. Comparison of sprint and run times with performance on the Wingate anaerobic test. Res. Quart. 1985;56:73-76.

24. Thorstensson A. Muscle strength, fibre types and enzyme activities in man. Acta Physiol. Scand. 1976; Suppl. 443.

25. Thorstensson A, Grimby G, Karlsson J. Force-velocity relations and fibre composition in human knee extensor muscles. J. Appl. Physiol. 1976;40:12-16.

26. Vogel JA, Patton JF, Mello RA, Daniels WL. An analysis of aerobic capacity in a large United States population. J. Appl. Physiol. In Press.

Table 1. Descriptive statistics of anaerobic power tests.

	Mean	SD
Wingate Test		
Peak Power (PP), W	783	85
W/kg	10.27	0.93
Mean Power (MP), W	611	57
W/kg	8.03	0.68
Power Decrease (PD), %	39.5	7.6
Isokinetic Endurance Test		
Highest Peak Torque (HPT), Nm	121.2	21.2
Nm/kg	1.60	0.27
Mean Peak Torque (MPT), Nm	76.5	12.8
Nm/kg	1.01	0.16
Peak Torque Decrease (PTD), %	62.3	6.6
Margaria Test		
Velocity, m/s	1.49	0.13
Power Output, W	1117	127
W/kg	14.7	1.3
Sprints		
50 m, s	7.14	0.27
200 m, s	28.76	1.64

Table 2. Correlation coefficients between the Wingate and isokinetic endurance tests

	Wingate Test				
Isokinetic Endurance Test	PP, W	PP, W/kg	MP, W	MP, W/kg	PD,%
HPT, Nm	0.632*	-	0.689**	-	-
Nm/kg	-	0.678**	-	0.761***	-
MPT, Nm	0.564*		0.715**		-
Nm/kg	-	0.521*		0.710**	-
PTD, %					-0.147

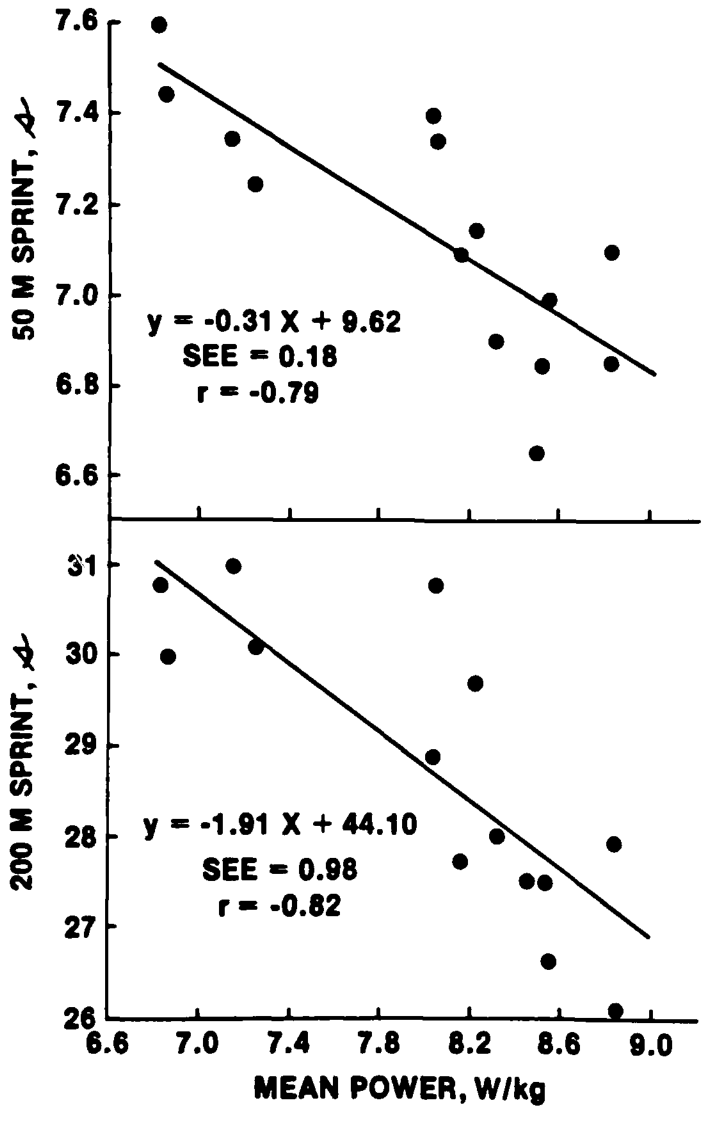
* p<.05; ** p<.01; *** p<.001

Table 3. Correlation coefficients for the Wingate and isokinetic endurance tests and other tests of anaerobic capacity.

	Sprints		Margaria	
Wingate	50 m,s	200 m,s	W	W/kg
PP, W	-0.527*	-0.118	0.620*	-
W/kg	-0.706**	-0.540*	-	0.639*
MP, W	-0.672**	-0.370	0.866***	-
W/kg	-0.790***	-0.819***	-	0.737**
PD, %	-0.038	0.238	-0.067	-0.338
Isokinetic Endurance				
HPT, Nm	-0.714**	-0.436	0.601*	-
Nm/kg	-0.737**	-0.641**	-	0.672**
MPT, Nm	-0.620*	-0.258	0.608*	-
Nm/kg	-0.649**	-0.459	-	0.569*
PTD, %	-0.361	-0.590*	0.069	0.606*

* p<.05; ** p<.01; *** p<.001

Figure 1. Relationship between mean power from the Wingate test and the timed sprints.



END

FILMED

2-86

DTIC