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Relationship Between a Two Mile Run For Time and Maximal Oxygen Uptake

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19. Abstract (continued)

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ABSTRACT

The purpose of this study was to examine the relationship between a maximal effort two-mile run for time and maximal oxygen uptake ($\dot{V}O_2max$) as measured by treadmill running. Subjects were forty-four males (aged 20-51) and seventeen females (aged 20-37) of various fitness and activity levels. All subjects performed a timed two mile run and a treadmill running test for maximal oxygen uptake. The coefficient of correlation between the treadmill maximal test and the two mile run test for all subjects was -0.91. Separate regression analyses for male and female data also displayed significant correlations (r_m = -0.91, r_f = -0.89). The addition of such variables as age, height, weight, and % body fat did not improve the predictability of the equations. However, inclusion of body weight in the male equation did increase its predictive accuracy (SEE = 3.31 to 2.69). The high degree of correlation between $\dot{V}O_2$ max and two mile run time thus permits the estimation of either component with significant accuracy from the direct measurement of the other. This study confirms the usefulness and validity of a timed 2 mile run test to indicate the level of aerobic fitness capacity when the test is properly supervised and the subjects are well-motivated.

Key Words: Aerobic fitness, Running performance, Predicted aerobic capacity, Maximal performance.

INTRODUCTION

It is generally accepted that a timed run of one to two miles, emphasizing individual effort, correlates reasonably well with a person's aerobic fitness as determined by maximal oxygen uptake ($\dot{V}O_2$max). A review of the literature does indicate many studies (2,3,5,6,7,10,12,14,15,20) comparing $\dot{V}O_2$max with a variety of field performance tests. These studies most often involved a relatively short, timed run of a specific distance (2,3,7,16,17,22), or an unlimited distance run for a specifically set time, e.g. 12 min (3,5,7.10,12). We have, however, found few reports of actual comparisons of a two mile run for time with treadmill $\dot{V}O_2$ max in a population including both genders and various ages and fitness levels.

The purpose of this study was to examine the relationship between a two mile run for time and $\dot{V}O_2$max as measured by treadmill running (9,11,13,19) in a group of men and women of various fitness and activity levels. Important aspects such as age, height, weight, % body fat, and relative fitness levels were also evaluated. From these data, simple regression equations were developed to predict the maximal aerobic capacity of both men and women from their 2 mile run performance.

METHODS

A group of sixty-one subjects consisting of 44 males and 17 females, ranging in age from 22 to 51, participated in this study. All subjects were given a full explanation of the study and their voluntary consent was obtained. All sub; ts were asked to perform two basic tests within fifteen days of each other: a timed 2-mile run on a measured, level, asphalt surface, and a treadmill determination of $\dot{V}O_2max$ (11,13). All subjects were medically screened and considered healthy prior to testing.

The treadmill test for maximal aerobic capacity was patterned on the methods described by Taylor et al. (19) and Mitchell et al. (13), and involved the use of interrupted runs at a constant speed with progressively increasing grades in order to achieve a plateau in oxygen consumption. The test began with a 3.5 mph familiarization walk at 0% grade for approximately 3 minutes. During this time, the Koegel breathing valve and noseclip were presented to the subject and the Douglas bag system was flushed. The test then proceeded with an initial warmup run of 5 or 6 mph at 0% grade for 6 minutes, immediately followed by a 5 to 10 minute rest period. Upon evaluation of the initial warmup load the speed of the treadmill remained constant but the intensity was progressively increased by raising the grade of the treadmill (2.0 - 2.5%) with each successive bout. Two to four additional runs were then performed, each 3 to 4 minutes long and interrupted by rest periods. During the last minute of each session, the subject breathed through a low resistance Koegel value while two 30 second Douglas bags of expired air were collected. A plateau, or decrease, in oxygen uptake with increasing exercise intensity was considered indicative of achieving $\dot{V}O_2max$. A plateau was defined as an increase of less than 2.0 ml/kg/min with an increase of 2.5% grade through two successive intensities.

Gas volumes were measured with a Collins 120 liter chain-compensated spirometer. Aliquots of expired air were analyzed for oxygen and carbon dioxide fractions with an Applied Electrochemistry fuel cell (MDL S-3A) and a Beckman LB-2 infrared carbon dioxide analyzer, respectively. Both gas analyzers were calibrated using primary certified gas standards (Matheson Gas Company, Gloucester, MA) which were checked for accuracy against our own calibrated cylinders and daily outside air analyses. Heart rate was monitored using a modified V_5 electrocardiographic recording. Additional measurements made on each subject included height, weight, and skinfold thicknesses. Percent body fat (%BF) was estimated from four skinfold sites (bicep, tricep, subscapular and suprailiac) using the age and gender related equations of Durnin and Womersley (8).

The two mile run test was performed outdoors on a level, paved surface. The subjects ran in PT clothes and running shoes. Each subject was asked to exert a maximal effort in covering the distance in the shortest possible time which was recorded to the nearest second by digital stopwatches.

In order to determine the effects of gender on $\dot{V}O_2max$ and two mile run time, a t-test comparing slopes of the male and female regression lines was completed on all performance data (17). The existence of separate gender regression lines was confirmed. Simple male and female regression equations were developed and t-tests and confidence limits determined on the two separate slopes. Additional prediction equations were then evaluated through stepwise, multiple regression analysis and examined to see if the estimation of $\dot{V}O_2max$ from 2-mile run time might be improved through the incorporation of such anthropometric variables as age, %body fat, height, or weight.

RESULTS

Table 1 presents the physical characteristics and performance results by gender. It is evident that the subject sample is characteristic of an active but not highly athletic population (20,21).

Table 2 presents the $\dot{V}O_2max$ and run time data divided into age groups as used to develop the regression equations presented in this study.

Separate examination of the male and female data on the relationship between $\dot{V}O_2max$ and 2-mile run time resulted in correlation coefficients of -0.91 and -0.89, respectively (Figure 1). Regression analysis of the entire sample (male plus female) resulted in a correlation coefficient of -0.91. The slopes of the regression lines between genders were found to be significantly different ($p < .001$). Comparision of males and females by independent t-test for the variables $\dot{V}O_2max$ and 2-mile run time resulted in significantly different values for both ($\dot{V}O_2max$: $t = 3.986$, $p<.001$; 2-mile run time: $t= 3.953$, $p<.001$). For this reason separate prediction equations of $\dot{V}O_2max$ based on 2 mile-run times were developed for each gender.

Tables 3 and 4 present a correlation matrix of the individual variables tested to improve the predictive power of the original equations. The highest correlation in both tables was the relationship of $\dot{V}O_2max$ and 2-mile run time. Other significant relationships ($p<.05$) occurred in the males between $\dot{V}O_2max$ and body weight, %. body fat and Ht/Wt ratio. These same anthropometric measures were also significantly correlated with 2 mile-run time. These relationships, however, did not hold true for females.

Both the original male and female equations a an additional equation for males are presented in Table 5. The first two equations describe the simple linear regression of $\dot{V}O_2max$ and 2-mile run time (r_m = -0.91, r_f = -0.89). The third equation, developed through a stepwise multiple regression of the variables in Table 3, resulted in a more accurate expression by including body weight (r = -0.941) to predict $\dot{V}O_2max$, thus resulting in an improvement in the accuracy of the estimate (S.E.E. from 3.31 to 2.69 ml/kg).

Table 6 presents male data comparing $\dot{V}O_2max$ as predicted from equations 1 and 3 of Table 5 to $\dot{V}O_2max$ determined directly on the treadmill for individuals who possessed the highest and lowest values for various anthropometric measures, aerobic power, and performance times. It can be seen that in 7 of the 11 categories, $\dot{V}O_2max$ as predicted using equation 3 was closer to the directly measured $\dot{V}O_2max$ value than that of equation 1.

DISCUSSION

Analysis of male and female data from this study demonstrated two distinct lines of regression. As such, individual regression equations were developed for each gender taking into consideration those variables which were significantly different for each gender and exerted any influence on the observed relationship ($\dot{V}O_2max$ vs 2-mile time). Johnson et al (12), had previously documented the need for a prediction model which recognized the separate performance characteristics of both men and women.

The results from this study corroborate the relationship that exists between a laboratory determination of maximal oxygen uptake and a field event of sufficient duration to allow energy production to occur primarily through aerobic rather than anaerobic pathways. This is in agreement with other studies (2,3,5,10,14,15) which reported similar findings. The relationship between aerobic fitness and 2-mile run time demonstrates that, over most of the range of measurement, male $\dot{V}O_2max$ values were higher than those of their female counterparts. This occurred in spite of the fact that more than half of the females tested were active joggers who ran two or more miles, three or more times weekly. Differences in body composition (% BF, LBM), blood hemoglobin concentration, and running style between the sexes may have accounted for this disparity. A comparison of 2-mile run times to $\dot{V}O_2max$ values determined per kilogram fat-free body weight (LBM) resulted in a smaller, but still significant, difference between the slopes of the male and female regression lines.

An examination of the data in Table 2 illustrates an interesting age-related phenomenon common to both men and women; that of decreasing $\dot{V}O_2max$ values with increasing age (1). Astrand states that $\dot{V}O_2max$ increases with age up to twenty years. However, beyond this age there is a general decline such that at age 60 one possesses only 70% of the $\dot{V}O_2max$ attained at age 25. He further states that regular physical training rather effectively counteracts the decline in maximal aerobic power which normally accompanies the aging process (1).

Nearly 82% of the total variance of the 2-mile run times was accounted for by $\dot{V}O_2max$. Cooper (5), Getchell (10), and Ribisl (15) also reported correlations of this magnitude, but in subject populations which were much more homogeneous in nature. For the sake of simplicity, it would be possible to use only the first two equations for the prediction of $\dot{V}O_2max$ and still have a very good relationship. The standard error of the estimate for both equations is approximately 3.0 ml O_2/kg/min, thus permittin a reasonably accurate estimate of aerobic capacity.

The addition of other variables such as height, weight and % body fat, to the original equation did improve the error of the estimate. In the male expression (Equation 1), the addition of weight alone improved the shared variance from 82 to 89%. Conversely, for the female expression (Equation 2), the addition of the height variable increased the amount of the shared variance from 80 to 86%. However, for purposes of developing a simple prediction equation, an effort was made to discover one common variable for both men and women which when added to the basic expressions would significantly improve the predictability of both equations. It was found that body weight was the single most significant variable (after 2-mile run time) which accounted for most of the remaining variance. Body weight was then incorporated into the regression equations for both sexes. Addition of body weight to equation 1 did improve the standard error of the estimate from 3.31 ml/kg/min to 2.69 ml/kg/min. However, inclusion of body weight in equation 2 resulted in no measurable difference to the S.E.E. of this expression. It is our opinion that the smaller sample size (N=17 females) used to derive equation 2 may have masked any improvement body weight might have produced to the S.E.E. of this expression. Equation 3 is included because of its improved predictive accuracy.

A comparison of the two main predictive models, (equations 1 and 3), with actual subject data spanning the widest range of anthropometric, physiological, and performance characteristics observed in the study is presented in Table 6. The predictive improvement of the regression expression with the inclusion of body weight is evident from this table. In most situations, the estimation of $\dot{V}O_2max$ was improved by the use of body weight. This improvement occurred equally over the entire range of values, including instances where the estimated $\dot{V}O_2max$ figure was both above and below the actual treadmill $\dot{V}O_2max$ determination.

PRACTICAL APPLICATIONS

This study has demonstrated that for average active subjects who are well motivated, the timed two mile run test is an excellent predictor of actual aerobic power.

Separate prediction equations were developed for each gender due to the nature of the respective performance results. Table 7 is presented to facilitate the conversion between two mile run time and $\dot{V}O_2max$ values.

TABLE 1. Physical Characteristics and Performance Results by Gender ($\bar{x} \pm SD$)

Variable	Male	Female
n	44	17
Age (yrs)	31.3 ± 6.	28.3 ± 4.0
Height(cm)	177.2 ± 6.3	165.3 ± 5.9
Weight(kg)	77.9 ± 9.2	60.9 ± 7.7
Body Fat (%)	18.3 ± 4.5	26.5 ± 4.1
Lean Body Mass (kg)	63.9 ± 6.3	44.5 ± 4.9
$\dot{V}O_2max$ (ml/kg/min)	50.4 ± 7.7	42.0 ± 6.0
2-Mile Time(min:sec)	14:44 ± 2:06	17:26 ± 3:01

TABLE 2. Relationship of Gender and Age to $\dot{V}O_2$ max, and 2-Mile Run Time

Age	Gender	n	$\dot{V}O_2$max	2-Mile Time
20-24	Male	9	54.1 ± 5.5	13:53 ± 1:32
	Female	4	43.4 ± 4.6	16:52 ± 2:28
25-29	Male	10	49.9 ± 4.8	14:49 ± 1.23
	Female	7	42.1 ± 6.5	17:15 ± 3:00
30-34	Male	14*	51.6 ±10.6	14:33 ± 3:04
	Female	4	42.1 ± 7.1	17:55 ± 3:22
35-39	Male	5	46.7 ± 7.3	15:42 ± 1:30
	Female	2	39.0 ± 8.8	18:14 ± 6:01
Over 40	Male	6	46.0 ± 5.1	15:25 ± 1:06

*Four Marathon Runners in this group.

TABLE 3. Correlation Matrix for Males

VARIABLE	1	2	3	4	5	6	7	8
1. $\dot{V}O_2max$(ml/kg.min)	1.00	-.91*	-.23	-.68	-.28	-.69	-.70	-.40
2. 2-Mile Run(min)		1.00	.18	.51	.21	.60	.53	.23
3. Age(yrs)			1.00	.19	.29	.43	.11	-.01
4. Weight(kg)				1.00	.60	.62	.96	.84
5. Height(cm)					1.00	.20	.35	.63
6. % Body Fat						1.00	.65	.15
7. Wt/Ht(kg/m)							1.00	.77
8. LBM(kg)								1.00

TABLE 4. Correlation Matrix for Females

VARIABLE	1	2	3	4	5	6	7	8
1. $\dot{V}O_2max$(ml/kg.min)	1.00	-.89*	-.16	-.24	-.24	-.22	-.21	-.20
2. 2-Mile Run(min)		1.00	.10	.23	-.02	.35	.28	.11
3. Age(yrs)			1.00	-.06	-.33	.24	.04	-.17
4. Weight(kg)				1.00	.53	.47	.96	.89
5. Height(cm)					1.00	-.22	.28	.74
6. % Body Fat						1.00	.60	.03
7. Wt/Ht(kg/m)							1.00	.77
8. LBM(kg)								1.00

TABLE 5. Equatio-- for the Prediction of $\dot{V}O_2max$ from 2-Mile Run Time

Equation 1: Male Run Time Only

$$\text{Pred.}\dot{V}O_2max = 99.7 - 3.35\,x$$

x = 2 Mile Run Time(min)

$r = -0.906$

$r^2 = 0.821$

SEE = 3.31

Equation 2: Female Run Time Only

$$\text{Pred.}\dot{V}O_2max = 72.9 - 1.77\,x$$

x = 2 Mile Run Time(min)

$r = -0.892$

$r^2 = 0.796$

SEE = 2.78

Equation 3: Male Run Time + Weight

$$\text{Pred.}\dot{V}O_2max = 110.9 - 2.79x_1 - 0.25x_2$$

x_1 = 2 Mile Run Time(min)

X_2 = Wt(kg)

$r = -0.941$

$r^2 = 0.885$

SEE = 2.69

TABLE 6. Equation Comparison ($\dot{V}O_2max$ = ml/kg/min)

INDIVIDUAL	TREADMILL $\dot{V}O_2max$	PREDICTED $\dot{V}O_2max$ Equation 1	PREDICTED $\dot{V}O_2max$ Equation 3	BEST PREDICTIVE EQUATION
Highest $\dot{V}O_2max$	66.1	63.2	63.4	-
Lowest $\dot{V}O_2max$	37.4	37.8	34.5	1
Fastest 2-mile(10:15)	65.7	65.4	64.1	1
Slowest 2-mile(18:56)	42.0	36.4	38.9	3
Heaviest Weight	37.4	37.8	34.5	1
Lightest Weight	66.0	62.1	65.0	3
Highest % BF	38.8	42.3	41.7	3
Lowest % BF	58.1	58.9	58.4	3
Highest LBM	44.4	48.5	44.4	3
High $\dot{V}O_2max$/Slow Run Time	60.1	53.5	56.2	3
Low $\dot{V}O_2max$/Fast Run Time	41.8	47.8	45.0	3

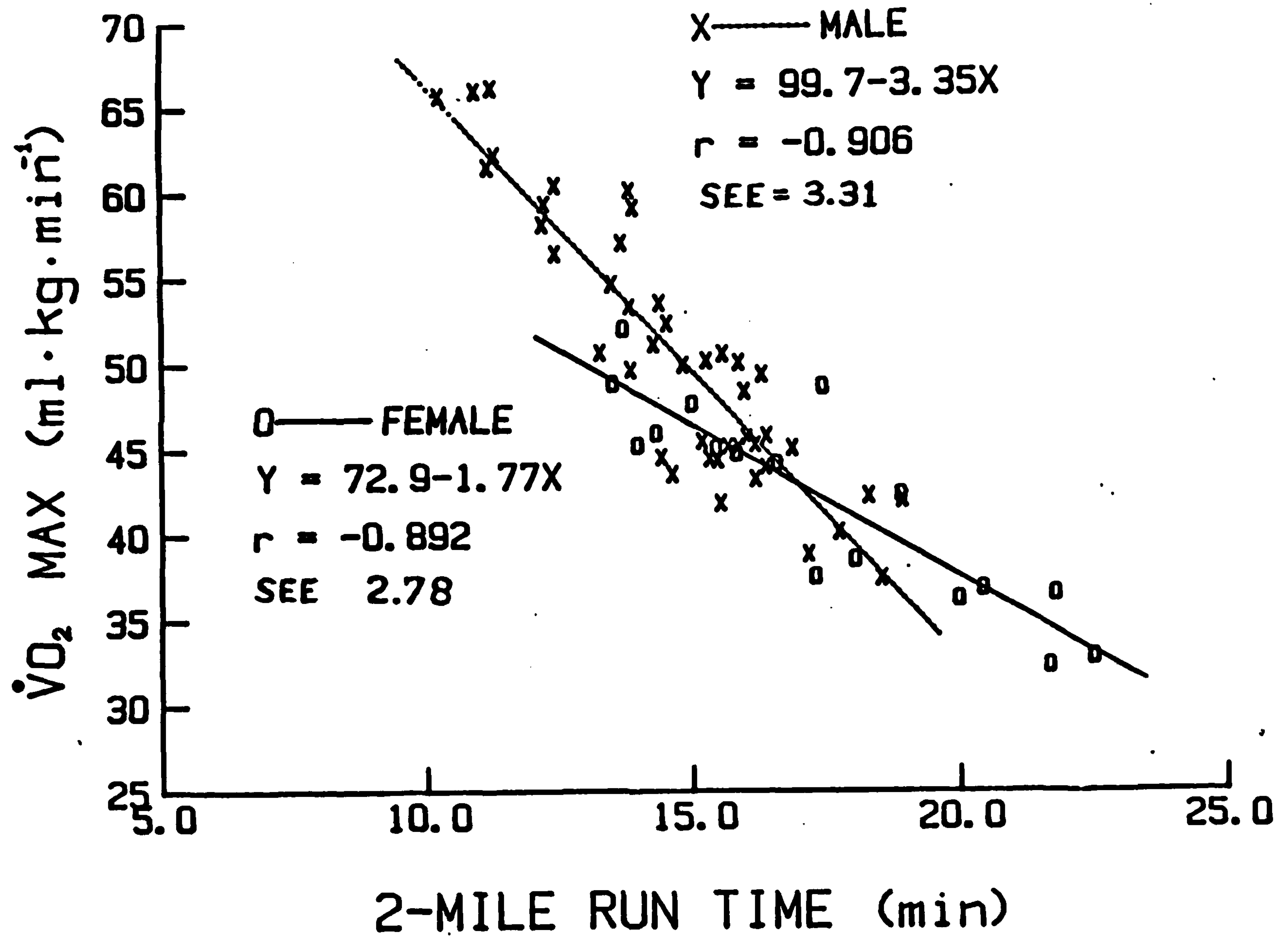
TABLE 7. Conversion of two mile run time $\dot{V}O_2max$ values.

2-Mile Run Time *	$\dot{V}O_2max$ # Male	Female
10.0	66.2	
10.5	64.5	
11.0	62.8	
11.5	61.2	
12.0	59.5	
12.5	57.8	
13.0	56.2	49.9
13.5	54.5	49.0
14.0	52.8	48.1
14.5	51.1	47.2
15.0	49.5	46.4
15.5	47.8	45.5
16.0	46.1	44.6
16.5	44.4	43.7
17.0	42.8	42.8
17.5	41.1	41.9
18.0	39.4	41.0
18.5	37.7	40.2
19.0	36.1	39.3
19.5	34.4	38.4
20.0	32.7	37.5
20.5		36.6
21.0		35.7
21.5		34.8
22.0		34.0
22.5		33.1
23.0		32.2

* Minutes # ml/kg/min

FIGURE LEGEND

FIGURE 1. Relationship of $\dot{V}O_2max$ to 2-Mile Run Time (Males and Females)



X——MALE
Y = 99.7-3.35X
r = -0.906
SEE = 3.31
O——FEMALE
Y = 72.9-1.77X
r = -0.892
SEE 2.78
VO2 MAX (ml·kg·min-1)
2-MILE RUN TIME (min)
70
65
60
55
50
45
40
35
30
25
5.0
10.0
15.0
20.0
25.0

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