ABSTRACT

VAN SKYHAWK, S. C. A comparative analysis of the one-mile field test to actual maximal oxygen consumption values in college males. M. S. in Adult Fitness/Cardiac Rehabilitation, 1989, 48 pp. (N. K. Butts).

34 healthy college male volunteers, 18-29 yrs, performed an actual VO_2max test and 2, one-mile walks for time. Each S's age, wt (lbs), gender, HR responses, and time during a one-mile walk were obtained to calculate VO_2max, both absolute ($l \cdot min^{-1}$) and relative ($ml \cdot kg^{-1} \cdot min^{-1}$) values using Kline's et al. (1987) equations. These prediction VO_2max values, using general and sex-specific equations, were correlated with actual VO_2max values using a Pearson Product Moment correlation. The results were:

Correlation between actual and predicted VO_2max values

	Walk 1		Walk 2	
	general	male-specific	general	male-specific
VO_2max ($l \cdot min^{-1}$)	0.79	0.79	0.75	0.75
VO_2max ($ml \cdot kg^{-1} \cdot min^{-1}$)	0.85	0.86	0.82	0.82

$p < 0.001$ between predicted and actual VO_2max

Each r correlation coefficient was sig at the 0.001 level. A dependent t-test indicated that actual VO_2max was sig ($p < 0.01$) higher than predicted VO_2max, both absolute and relative. Due to the moderately high r, however, it was concluded that the equations developed by Kline et al. (1987) can be used to predict VO_2max values in college-age males, but may result in a slight underestimation.

A Comparative Analysis of the One-Mile Field Test to Actual Maximal Oxygen Consumption in College Males

A Thesis Presented

to

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by

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CHAPTER I

INTRODUCTION

Background

Maximum oxygen consumption (VO_2max) measurements are used to determine the maximal rate at which the body consumes and utilizes oxygen for aerobic metabolism. The value obtained during a VO_2max test is commonly used to assess the cardio-respiratory fitness of an individual and is the most accurate measurement of fitness currently in use (Pollock, Wilmore, & Fox, 1984). Obtaining actual VO_2max values involves expensive and complicated equipment, is impractical when testing large groups, and is exhausting to the subject. For these reasons, many prediction tests have been developed that involve submaximal workloads which are easier to administer and are less strenuous for the individual being tested. Some of the most common or well known prediction tests include Cooper's 12-minute Run (Cooper, 1968) and the YMCA Bicycle Ergometer Test (Golding, Myers, & Sinning, 1982). Prediction VO_2max tests are useful in many educational and fitness evaluation settings that cannot afford equipment used for actual VO_2max values (ACSM, 1986). Just as actual VO_2max tests, prediction tests can vary in mode and protocol. The type of prediction test used to acquire VO_2max values should be specific to the mode of exercise an individual is currently participating in (McConnell, 1988). It is logical, therefore, that this should be the case when using prediction tests.

In the past few years, walking has been promoted due to the frequency of joint injury seen with running (Sheehan, 1986). Even if running is continued, Garrick and Radetsky (1988) suggest intermittent running with walking. More of the adult population has turned to exercising and the mode frequently chosen is walking since it can be done by almost anyone at any age (Rippe, Ward, Haskell, Freedson, Franklin, & Campbell, 1986). Walking has also been found to be effective in aerobic conditioning at an appropriate intensity and duration (Jonas & Radetsky, 1988).

Recently a new VO_2max prediction test has been developed that involves walking. Kline et al. (1987) developed a VO_2max prediction test which will be referred to as the One-Mile Walk for Time. As stated above, popularity of walking has increased and Kline's et al. (1987) prediction test could serve as the best means of evaluating cardio-respiratory fitness for the population of walkers without having to perform an actual VO_2max test.

In the study by Kline et al. (1987), the authors tested a large sample (n=343) with a large range in age (30-69 years). One reason for this wide range was to create an equation that would have a "generalized application to a broad population." The equation developed included other variables besides age including body weight, gender, and the time an individual took to walk one-mile. The results showed a high correlation with a cross validation group ($r = 0.92$; SEE = .355 $l \cdot min^{-1}$). Kline et al. (1987) concluded that the one-mile walk for time resulted in a valid test for the prediction of VO_2max. However, Jackson and Coleman (1976) stated that test validity for one population may or may not prove to be valid for a different population. Therefore, this study addresses the appropriateness of using the one-mile walk for time test in a population of college males between the ages of 18-29 years.

Purpose

The primary purpose of this study was to determine if the one-mile walk for time field test by Kline et al. (1987) accurately predicts VO_2max in college males ranging in age between 18-29 years. This was done by comparing actual VO_2max values from a treadmill protocol with the predicted VO_2max values from the one-mile walk and using the equations developed by Kline et al. (1987).

The secondary purpose of this study was to develop an equation that would be valid for the younger population if, in fact, a low correlation resulted between actual to predicted VO_2max tests when using the equations by Kline et al. (1987).

Need for the Study

The need for the study was to provide a prediction VO_2max walking test that would be both valid and reliable in estimating VO_2max in college males ranging in age between 18-29 years.

Hypothesis

In this study a null hypothesis was stated: there would be no correlation between actual VO_2max test and the One-Mile Walk for Time field test by Kline et al. (1987) in college males between the ages of 18-29 years.

Assumptions

The following assumptions were made for this study:

1. All subjects were free of physical limitations and in good health.

2. All subjects felt comfortable running on the treadmill.

3. Each subject obtained a true VO_2max on the treadmill protocol.

4. During the two, one-mile walks the subjects walked as fast as possible without "running".

5. All equipment used during testing was functional with no defects.

6. All subjects refrained from smoking, eating, and ingesting alcohol or caffeinated beverages four hours prior to testing.

7. All subjects did not exercise the same day prior to testing.

Delimitations

The delimitations of this study were:

1. The sample chosen was limited to college males ranging in age between 18-29 years attending the University of Wisconsin-La Crosse Spring Semester 1989.

2. Both the one-mile walks and the actual VO_2max test were performed within a two week time period.

Limitations

The limitations of this study were:

1. The sample was not random in nature but obtained on a volunteer basis.

2. Motivation, activity level, and health changes could not be controlled and may have affected performance during testing.

3. It was difficult to determine if, during the one-mile walks, the subjects walked as fast as possible.

4. Although a practice session was provided for each subject, those subjects who had performed a VO_2max test prior to this study may have had a learning effect.

Definition of Terms

Maximal oxygen consumption (VO_2max) - maximal amount of oxygen an individual can intake, transport, and utilize per minute and is considered to be an indicator of cardio-respiratory fitness. This was measured using the Beckman Metabolic Measuring Cart using Butts' (1982) Protocol for the treadmill. Respiratory Exchange Ratio, heart rate, and Borg's scale of Ratings of Perceived Exertion were used to determine if, in fact, the subject had reached maximal effort. VO_2max was expressed in both absolute ($l \cdot min^{-1}$) and relative ($ml \cdot kg^{-1} \cdot min^{-1}$.) units.

Running - a continuous exercise consisting of three phases of push off, flight, and landing.

Walking - a continuous exercise in which there is surface contact by one foot at all times.

Heart Rate - the frequency at which the heart pumps blood each minute. The heart rate was reported in beats per minute (bpm) using a heart rate monitoring device worn around the lower chest containing two electrodes which transmits heart rate to a watch either worn on the wrist or within 3.5 feet that displays the heart rate in bpm distributed by Uniq Computer Instruments Corporation (CIC).

Ratings of Perceived Exertion (RPE) - a subjective 15 point scale ranging between 6 to 20. Seven is considered to be very, very light while nineteen is considered very, very hard and maximal effort. The scale is used to determine how hard the subject feels he is working.

Respiratory Exchange Ratio (R) - volume of carbon dioxide produced over the volume of oxygen consumed. It reveals the relative contribution of nutrients, carbohydrates and fats, to energy yield. A ratio over 1.00 indicates the use of strictly glucose (carbohydrates) for fuel which indicates maximal effort due to the inability to take in more oxygen.

CHAPTER II

REVIEW OF RELATED LITERATURE

Introduction

Maximum oxygen consumption (VO_2max) is a measurement used to assess cardio-respiratory fitness. To measure VO_2max accurately, direct measurements are obtained along with exercise protocols which utilize work loads to maximal effort (Kline et al., 1987; Fitchett, 1985). Many health-related facilities which desire measurement of VO_2max may not have available space and/or the finances to purchase the extensive equipment necessary for maximal testing. For these reasons many tests have been developed which use submaximal workloads and different modes of exercise to predict VO_2max. Predicting VO_2max is not only less expensive, but less exhausting for the participants, less risk of injury, less time consuming, and easier to administrate. In addition, submaximal tests allow the testing of large numbers of people in a small amount of time (Paliczka, Nichols, & Boreham, 1987; Farwell & Mayhew 1983; Astrand & Ryhming, 1954).

This chapter is a review of the literature concerning VO_2max including a brief overview of the reasons for predictions tests, the assumptions on which they are based, the importance of specificity, and a discussion of the fairly recent prediction test which involves walking. First, however, the explanation of directly measured VO_2max

tests will be discussed since prediction tests are compared to this standard to determine VO_2max prediction test accuracy.

Maximal Oxygen Consumption Measurement

Physical fitness is best assessed by measuring the cardio-respiratory systems through determination of VO_2max (Pollock et al., 1984; Jackson & Squires, 1982; Ribisl & Kachadorian, 1969; Rowell, Taylor, & Wang, 1964; Astrand & Ryhming, 1954). Such measurements are used to determine an individual's working capacity which can be defined as the "total energy available used to perform work" (Boulay, Lortie, Simoneau, Hamel, Leblanc, & Bouchard, 1985, p. 325). Maximal oxygen consumption is considered an international standard for assessing work capacity by measuring cardio-respiratory and skeletal muscle capabilities (McConnell, 1988; Fox, 1984; Jackson & Squires, 1982).

Maximal oxygen consumption can be divided into a function of three metabolic states. The first state is considered the submaximal state, or aerobic state, in which the body increases the amount of oxygen it uses until the body adjusts to the constant workload. Secondly, there is the anaerobic threshold, where the body crosses over to an anaerobic state when oxygen demands cannot be met solely through the aerobic process. Lastly, is the maximal state, when the body is performing using anaerobic metabolism only until cardiovascular fatigue results (Jackson & Squires, 1982).

Methods of Determining VO_2max

In an average individual VO_2max is usually determined by means of a treadmill protocol that increases the work load in stages until maximal effort is reached. However, the best method used to determine VO_2max is controversial (Fichett, 1985). McConnell (1988) stated that the method used to determine VO_2max should be measured on a motorized treadmill, because it has been shown to "allow the most efficient, valid and reproducible VO_2max values in a controlled testing environment" (p. 57). However, Davies, Daggett, and Mulhull (1984) found no significant difference with motorized to nonmotorized treadmill results when measuring VO_2max. In fact, they reported slightly higher VO_2max values when testing on a nonmotorized treadmill.

Treadmill protocols, either nonmotorized or motorized, do elicit higher VO_2max values than other modes of testing in most individuals. In the study by Glassford, Baycroft, Sedgwick, and Macnab (1965), four techniques of VO_2max testing were compared. Three of the four were actual VO_2max tests; two treadmill protocols and one cycle ergometer protocol. The results indicated that the two treadmill protocols were comparable in both absolute VO_2max ($l \cdot min^{-1}$) and relative VO_2max ($ml \cdot kg^{-1} \cdot min^{-1}$) values. The cycle ergometer protocol, however, resulted in a lower magnitude for both VO_2max measures in absolute and relative terms.

Likewise, McConnell, Swett, Jeresaty, Misski, and Al-Hani (1984) compared treadmill, cycle ergometer, supine cycle ergometer, and arm ergometer modalities in VO_2max testing. Results indicated that the treadmill protocol produced higher VO_2max ($ml \cdot kg^{-1} \cdot min^{-1}$) values when compared to the cycle ergometer, the supine cycle ergometer, and the arm ergometer.

Magel, Foglia, McArdle, Gutin, Pechar, and Katch (1975), however, argue that the mode chosen for VO_2max testing should be specific to the sport in which the individual trains, especially when testing pre and post-training to indicate a training effect. They studied college-aged males (n = 30) who participated in recreational swimming. Fifteen were placed into a control group while the remaining participated in a ten week training swimming program. A treadmill VO_2max and a tethered swim VO_2max test were administered both pre and post-training. The authors found no significant difference between the swim or treadmill VO_2max values in the control group after ten weeks, and no significant difference was found between the VO_2max values on the treadmill for the experimental group. They did, however, find there was a 15% increase in VO_2max values between the two swimming tests in the experimental group. This indicates specificity when testing, especially when measuring a training effect.

Astrand (1971) identified five requirements for VO_2max testing regardless of the modality used. First, the work performed must involve a large muscle mass. Secondly, there must be a means of measuring the workload and the ability to reproduce that same workload. Thirdly, the test administered must be such that the results and the conditions under which values are obtained are comparable and reproducible. Next, all healthy individuals must be able to endure the test, and finally, the skill required to be performed during the test must be unvaried within the population being tested.

Test Protocol

McConnell (1988) stated that for better reliablity the protocol used in VO_2max testing should increase in grade of the treadmill at a constant speed. A protocol developed using this theory was by Mitchell, Sproule, and Chapman (1958) to test 65 normal males. The discontinuous protocol increased 2.5% grade at each stage with a constant speed of 6 miles per hour (mph). Another protocol that increases in grade only is by Bolter and Coutts (1987) to test competitive male runners. This protocol maintains a constant speed of 9 mph while increasing grade 1% at each stage, however, the stage length lasts only 30 seconds.

A slight modification of this theory is by Butts (1982) who studied female high school cross country runners. The continuous protocol developed in this study kept a constant speed of 6 mph while increasing the grade 2.5% every third minute, however, once 10% grade was reached, grade was held constant and speed increased 0.5 mph in subsequent stages.

Protocols for VO_2max testing may either be continuous or discontinuous. Continuous protocols do not allow for any rest periods during the maximal test (Butts, 1982; Bruce, Kusumi, & Hosmer, 1973). Discontinuous protocols, however, enables the individual being tested to rest between stages (Mitchell et al., 1958; Taylor, Buskirk, & Henschel, 1955). Continuous protocols are advantageous due to the decreased time of the test when compared to discontinuos protocols. McArdle, Katch, and Pechar (1973) concluded that there was no difference between continuous and discontinuous protocols when determining VO_2max.

The VO_2max test should include a warm-up phase, especially with heavy workloads, which may already be included in the protocol. The suggested warm-up is approximately 5-10 minutes at 50 per cent of estimated maximal work capacity (Astrand & Rhodal, 1977, p. 297). Taylor et al. (1955) allowed a warm-up from 10 minutes to one hour at a set work load, but the subjects were allowed five minutes to rest prior to actual testing protocol.

Following the warm-up phase, maximal effort should be attained within 5-10 minutes for the purpose of rapidly obtaining the full limitation of the aerobic process, and thus less likely to rely on the anaerobic process (Astrand & Rhodal, 1977, p. 298).

One of the earliest VO_2max test was by Taylor et al. (1955). They claimed that VO_2max can be reached in 1.5 minutes, therefore, their protocol was completed in a much shorter time. Before the test began, the physical fitness of the subject was determined by the Harvard Fitness Test, which determines what per cent grade the subject starts the test. After the warm-up and a rest period the test began at the predetermined grade and at a speed of 7 mph. The test length is a total of three minutes which allowed for gas collection one minute after peak VO_2 along with a 30 second leeway.

There are many protocols such as those developed by Bolter and Coutts (1987), Butts (1982), Bruce et al. (1973), Mitchell et al. (1958), and Taylor et al. (1955). However, minor adaptations may be necessary when testing due to differences between individuals, but these adaptions do not affect the validity and reliablilty of the VO_2max test (McConnell, 1988).

Maximal Oxygen Consumption Prediction Tests

As a result of disadvantages of VO_2max testing, submaximal tests have been developed that predict VO_2max. These tests provide advantages over actual VO_2max testing by allowing more comfort to the individual being tested while still obtaining valid and reproducible measures of functional capacity (deVries & Klafs, 1965).

High validity and reliable measures were found in a study by Doolittle and Bigbee (1968) studying males in the ninth grade (n = 153) which resulted in a test-retest reliablity of 0.94 using a 12-minute prediction test. Validity was 0.90 when nine of the subjects' prediction VO_2max values were correlated with measured VO_2max.

Assumptions

Prediction tests are based on various assumptions. One assumption is that within a given range oxygen uptake is linearly related to running speed (Margaria, Cerretelli, Aghemo, & Sassi, 1963; Henry, 1953) both for the trained and untrained, male and female (Dolgener, 1982). However, Bruce et al. (1973) implied that this relationship is curvilinear when VO_2max is compared to performance. Foster et al. (1984) evaluated responses when utilizing the Bruce protocol. The subjects (n = 200) had a large range of health and fitness levels from symptomatic angina patients to trained athletes. Each subject performed a treadmill symptom limited exercise test using Bruce's et al. (1973) protocol. The last full minute ventilation during the protocol was accepted as VO_2max as long as RER was greater than 1.0 and/or the performance was subjectively determined as maximal effort. The authors then performed a regression analysis which resulted in a curvilinear response of VO_2max to performance, but suggested that the curvilinear relationship is due to the large incremental increase of work loads with the Bruce protocol.

Another assumption is that there is a linear relationship of VO_2max with heart rate response (Astrand & Ryhming, 1954). Fitchett (1985) stated:

> The most popular methods of sub-maximal testing have been those which predict VO_2max by extrapolation from the relationship of sub-maximal VO_2 and heart rate values to an assumed age-related maximum heart rate. (p. 85)
>
> The basis for the prediction of VO_2max from the extrapolation of the sub-maximal relationship between oxygen uptake and heart rate values rests on two major assumptions. First, that the heart rate is linearly related to oxygen uptake over a wide range of work-loads from 50-100% of oxygen consumption and secondly that all subjects within a population age group are able to reach similar maximal heart rates. (p. 87)

Davies (1968), however, stated that this relationship of heart rate to VO_2max breaks down at higher work loads regardless of age group testing, thus resulting in an underestimation of VO_2max. With heart rate relationships, deVries and Klafs (1965) concluded that heart rate has a higher predictive value when heart rate is taken during exercise with differing incremental workloads rather than heart rate during recovery.

Still another assumption indicates that VO_2 is linear with cardiac output (Yamaguchi, Komatsu, & Miyazawa, 1986). Astrand and Rodahl (1977, p.180), however, claim this is a curvilinear relationship.

Because regression equations are used to develop estimation of VO_2max, prediction VO_2max tests can be both reliable and accurate (Kline et al., 1987). Equations developed through regression techniques, however, are based on specific populations, therefore, the equation is limited and may not apply to differing populations (Foster et al., 1984). Age, for instance, may be a limiting factor for certain prediction tests. For example, with increasing age an individual's level of activity declines, there is an increased chance in developing disease, and usually an increase in percent body fat. These factors may then, in turn, lower an older individual's VO_2max (Heath, Hagberg, Ehsani, & Holloszy, 1981). Due to these factors, prediction VO_2max tests based on an older population may not be appropriate for a younger, healthier population.

Specificity of Prediction Tests

Submaximal prediction tests incorporate a wide variety of exercise modes (see Table 1) to enable specificity as well as convenience of testing dependent on the equipment available.

One of the earliest prediction tests was developed by Astrand and Ryhming in 1954. They developed a nomogram which could be used with a variety of modes of exercise including cycle ergometer, treadmill, and step test. The nomogram determines VO_2max from a single work load and heart rate at that specific work load. The nomogram was developed from data on well trained male subjects (n = 27) and female subjects (n = 31) between the ages of 20 to 30 years.

Since Astrand and Ryhming were leaders in developing such tests, many researchers have been interested in testing the validity of this test.

Table 1. Comparison of various prediction VO_2max tests that include healthy subjects (H), trained subjects (T), and varied health and fitness level subjects (V). Gender of the subjects includes males (M) or females (F) or both (B). Correlation (R) is provided as well as standard error of estimate (SEE).

Study	N, Sex Class	Age(yrs)	Test Type	VO_2max (a) $l \cdot min^{-1}$ (b) $ml \cdot kg^{-1} \cdot min^{-1}$	R	SEE
Kline et al. (1987)	343 B(H)	30-69	one-mile walk	(a) 2.67 ± 0.87 (b) 37.1 ± 9.1	.92 .88	0.34 4.40
Coleman et al. (1988)	90 B(H)	20-29	one-mile walk	(b) 49.5 ± 5.3	.79	5.68
Cooper (1968)	115 M(H)	17-52	12-minute run/walk	—	.90	—
Doolittle et al. (1968)	9 M(H)	14-15	12-minute run/walk	—	.90	—
Bonen et al. (1979)	100 M(H)	7-15	treadmill	(a) 1.77 ± 0.52 (b) 48.3 ± 5.1	.95 .62	0.17 4.10
Foster et al.[a] (1984)	200 M(V)	16-48	treadmill	(b) 39.4 ± 15.8	.98	—
Glassford et al.[b] (1965)	23 M(H)	17-33	cycle ergometer	(a) 3.16 ± 0.84	.80	—
Siconoefi et al. (1982)	63 B(H)	20-70	cycle ergometer	(a) 2.09 ± 0.73	.94	0.25
Paliczka et al. (1987)	9 M(T)	26-47	20-metre shuttle run	(b) 59.9 ± 9.9	.93	2.89

[a]The study by Foster et al. (1984) included symptomatic anginal patients (n=14), postmyocardial revascularization surgery patients (n=36), preventative medicine participants (n=90), and athletes (n=27). The correlation provided is from the equation that incorporates both health statis and activity level.
[b]Glassford's et al. (1965) included the Astrand-Ryhming indirect prediction test.

Such is the case for Rowell et al. (1964) who studied four differing groups of males between the ages of 18 to 24 years. One group (n = 10), included endurance athletes of various intercollegiate sports (runners, swimmers, and a skater) which was similar to those used by Astrand and Ryhming (1954) to develop the nomogram. Each subject performed a VO_2max test which was compared to the results obtained when predicting VO_2max from the nomogram from treadmill performance. Observed VO_2max was underestimated by 5.6% ± 4.2% when compared to predicted value from the nomogram.

A second group (n = 7) consisted of sedentary males without athletic experience. Maximal oxygen consumption, both actual and predicted, was determined before and after a conditioning program. Before training, VO_2max predicted on the nomogram was 26.8% ± 7.2% less than observed VO_2max. This underestimation decreased, however, as a result of training to 13.7%. This is still a greater underestimation when compared to the athletic group of 5.6%. They concluded that the more physically fit the subject was, the closer the estimation of VO_2max was to observed values.

deVries and Klafs (1965) studied an array of prediction tests including Astrand and Ryhming's (1954) nomogram. Sixteen active male subjects between the ages of 20-26 years volunteered to participate in six prediction VO_2max tests that would be correlated with actual VO_2max values. The results indicated a moderate to high correlation when using the Sjostrand prediction cycle ergometer test (r = 0.87), the Harvard Bench test (r = 0.77), Astrand and Ryhming test using the cycle ergometer (r = 0.74), and the Progressive Pulse Ratio (r = 0.71). The remaining two tests resulted in low correlations.

Prediction tests can also provide estimation of performance without having to obtain true VO_2max. Farwell and Mayhew (1983) claim that as tasks become more similar in testing and performance, the more appropriate that particular test is for predicting performance. In their study they compared three submaximal prediction VO_2max tests to the performance in a 12-minute run. The prediction tests included Astrand-Ryhming (1954) cycle ergometer test as modified by Astrand (1960), Astrand-Ryhming nomogram for bench stepping, and the Bruce et al. (1973) protocol for the treadmill using sex-specific equations. The subjects consisted of both males (n = 50) and females (n = 70). The results indicated that for the males a higher correlation (r = 0.60) occurred between the 12-minute run performance when compared to the similar activity of the treadmill test. However, the females' performance correlated (r = 0.69) higher with the bench step. The authors still recommended task specific tests to predict performance.

Field Prediction Tests

Field tests are especially useful and valid in predicting VO_2 max. Equipment as minimal as a stopwatch is all that is required to carry out most tests of this type.

Ribisl and Kachadorian (1969) developed a prediction equation for both middle age males (30-48 yrs) and college-age males (18-22 yrs) using a two-mile run for best time. In addition, a 440 yard dash and 100 yard dash for time were incorporated in the regression equation for college-aged males. Results indicate a high correlation when predicted VO_2max was compared to actual VO_2max for the middle age population ($r = 0.86$) and college-aged population ($r = 0.85$).

Cooper (1968) developed a popular field test which nvolves a 12-minute run/walk. Cooper studied male Air Force officers and airmen ($n = 115$) between the ages of 17 to 52 years, however, the average age was 22 years. Each subject performed at least two 12-minute runs and the longest distance was recorded. The distance was plotted against actual VO_2max which was measured on a treadmill. The results indicated a high correlation ($r = 0.90$). The author concluded that this was a good test in assessing VO_2max. However, this test is recommeded for young, well motivated male subjects because motivation plays a role in the accuracy of this test.

Recently, the one-mile walk field test by Kline et al. (1987) was develop that included an age range of 30-69 years. A walking test was developed due to the ease and convenience of walking, and also to encompass a broad population with an accurate prediction test.

Walking as Exercise

Walking is a skill that most everyone has been doing since youth. Until recently, however, walking has not been considered an "exercise", or an activity which improves physical conditioning (Rippe, Ward, et al., 1986). Currently, the number of walkers has increased because most any one can do it at any age (Jonas & Radesky, 1988, p. 3) along with companionship (Rippe, Ward, et al. 1986). Many walking clubs have come into existance all over the United States and Canada. As many as 1,300 clubs are available for individuals with many different walking interests such as mallwalkers, racewalkers, and day hikers (Raben Magazine Venture, 1988, pp. 81-160). In addition, walking has been found to improve physical fitness when incorporating appropriate intensity and duration (Sheehan, 1986).

The heart rate responses during exercise are important in the improvement of cardiovascular system. Since heart rate does not distinguish between differing exercises, walking can improve physical conditioning (Jonas & Radesky, 1988, p. 3). Walking at appropriate level for continuous amount of time is effective in developing cardio-respiratory fitness (Sheehan, 1986). In 1986, McCarron, Kline, Freedson, Ward, and Rippe determined that fast walking was adequate for high fit males in order to obtain aerobic benefit. Of the ten male subjects studied, all had heart rates between 70-87.5% of maximal heart rate when walking.

With walking it is possible to increase both the intensity and duration of exercise through training. There is a level of speed where walking is more economical than running (Margaria et al., 1963). In an earlier study by Margaria, it was concluded that speed, under 8.5 kilometer per hour (km/hr) or 5.28 mph, walking is more economical than running. However, at a speed above 8.5 km/hr running is more economical than walking. Franklin, Pamatmat, Johnson, Scherf, Mitchell, and Rubenfire (1983) stated that the optimal speed of walking is at a "speed at which energy expenditure per meter is minimal" (i.e., 2.4 to 3.1 mph).

Walking has also been promoted due to less injury when compared to running (Sheehan, 1986). A recent issue of The Physician and

Sportsmedicine (Rippe, Ward, et al., 1986) presented a round table discussion, which included a panel of six experts on walking. This discussion indicated that when comparing the measurement of ground reaction forces, running normally produces forces three times body weight. With walking, however, the greatest force observed has only been 1.25 times body weight.

Walking Prediction Tests

Since walking has become more popular, a prediction test which incorporates walking would be valuable to estimate an individual's VO_2max values. Recently, Kline et al. (1987) developed a prediction equation which included variables of gender, age, weight, heart rate and time from a one-mile walk. The study included both male and female subjects (n = 343), between the ages of 30 to 69 years with varied activity levels. Regression equations were calculated on the basis of the results which included both general and sex-specific equations expressed in absolute ($l \cdot min^{-1}$) and relative ($ml \cdot kg^{-1} \cdot min^{-1}$) values.

Jackson and Coleman (1976) indicated that when an equation is both reliable and valid for a certain population, it may or may not be valid for a differing population. Therefore, Coleman et al. (1987) duplicated the study by Kline et al. (1987) in a younger population (20-29 years). Ninety subjects, both male (n = 40) and female (n = 50), performed a treadmill VO_2max test and on a separate date performed a one-mile walk for time. The variables obtained during each one-mile walk were then computed in the following generalized equation developed by Kline et al. (1987):

$$VO_2\ (ml \cdot kg^{-1} \cdot min^{-1}) = 132.853 - 0.0769*WT - 0.3877*AGE + 6.315*SEX - 3.2649*T1 - 0.1565*HR$$

Variables include: Weight (WT) in pounds, Age, Sex (male = 1, female = 0), walk time (T1), and heart rate (HR) (p. 256)

Results indicated moderate correlation between prediction VO_2max and actual VO_2max of the group as a whole ($r = 0.79$), for males ($r = 0.79$), and for females ($r = 0.62$). The authors concluded this test provided a valid estimation of VO_2max for that age group.

Summary

Maximal oxygen comsumption is determined primarily using a continuous treadmill protocol and by measuring expired gases directly. The protocol used for the VO_2max test requires the subject to work at a maximal level to obtain accurate measurements. It is best to achieve VO_2max within 5 to 10 minutes after a warm-up phase. With a maximal test of this type, injuries may occur, a skilled technician is required, equipment is expensive, as well as the requirement for high subject motivation. These disadvantages lead to the need for estimating VO_2max through prediction tests.

A large number of prediction tests for VO_2max have been developed throughout the years. These test incorporate differing populations as well as differing modalities. Prediction VO_2max tests within the population can result in both valid and reliable values of VO_2max. These tests use a linear regression technique to develop equations valid for the particular population. The linear regression equations are based primarily on either the linear relationship between increasing VO_2 and increasing heart rate or increasing VO_2 and speed of running.

Field tests are popular in estimating VO_2max. Since walking has become more popular, the new prediction test by Kline et al. (1987) that involves a timed one-mile walk and other variables, such as heart rate, can serve as valuable instruments for testing in a university setting. However, Kline's et al. (1987) equations were developed on a population between the ages of 30 to 69 years. This study addresses the validity of the equations provided by Kline for the younger male population between the ages of 18-29 years.

CHAPTER III

METHODS

Introduction

In this study two different tests were administered both resulting in VO_2max both in absolute ($l \cdot min^{-1}$) and relative ($ml \cdot kg^{-1} \cdot min^{-1}$) values. One test was an actual maximal oxygen consumption test determined from expired gas analysis during treadmill running. The other test was a prediction of VO_2max that involved a timed one-mile walk, heart rate measurement during the last quarter mile, weight, age, and gender.

This chapter will present the methods of subject selection, development of instrumentation, experimental procedures, and method of statistical treatment.

Subject Selection

Thirty-four healthy male college students from the University of Wisconsin-La Crosse (UW-L) ranging in age between 18-29 years of age, volunteered to be subjects in this study. The majority of the volunteers were acquired through Personal Fitness courses (PE 114) and the Junior class in Physical Therapy at UW-L. A letter of permission (see Appendix A) was given to the instructors of PE 114 courses in order to obtain volunteers from their classes. The remaining subjects, also students from UW-L, were obtained through personal contact.

Prior to volunteering, the thesis topic was presented to the individuals and they were asked to participate in two, one-mile walks and an actual VO_2max test on the treadmill. The majority of the subjects indicated that they had not participated in an actual VO_2max test (n = 27) or a one-mile walk for time test (n = 31) prior to this study.

Development of Instrumentation

To acquire actual VO_2max values, open circuit gas analysis was used as well as heart rate determination and Ratings of Perceived Exertion (RPE) Borg's Scale. The one-mile walk for time also required heart rate determination. The following describes the instruments used during testing that enabled data collection.

Gas Analysis

Throughout the maximal treadmill protocol, gas analysis was obtained by using the Beckman Metabolic Measuring Cart (BMMC) [Wilmore, Davis, & Norton, 1976]. The BMMC is an open circuit system that analyzed expired gases at one minute intervals. Immediately pre- and post-testing, the oxygen analyzer (OM-11) and the carbon dioxide analyzer (LB-2) were calibrated using a standard gas mixture. Other calibrations of the BMMC included barometric pressure and room temperature (ambient air) obtained by mercury barometer and thermometer inside the testing area.

The subjects breathed through a non-rebreathing Rudolph valve connected to headgear to keep mouth piece comfortable and secure. The subjects were also required to wear a nose clip to ensure all air expired was collected through a tube connecting the mouth piece to the BMMC.

Gas parameters were automatically calculated at minute intervals of the test. These parameters include: minute ventilation (V_E), absolute and relative oxygen consumption (VO_2), expired carbon dioxide (CO_2), respiratory exchange ratio (R), fraction expired carbon dioxide ($FECO_2$), and fraction expired oxygen (FEO_2).

<u>Ratings of Perceived Exertion (RPE) Borg's Scale</u>

Prior to the treadmill VO_2max test, the Borg's RPE (Borg, 1973) [see Appendix B] was explained to each subject. The following instructions were given:

> "At various times throughout your run I will hold up this scale and ask you to select the number that best represents how hard you feel the work is for you at the time. As you can see this scale ranges from a low of 6 to a high of 20. The higher the number the harder you feel the effort is for you. The highest number (20) should represent the maximum effort and fatigue level you have ever felt while running. There is no right or wrong answer. Just try to estimate your total feeling of exertion and effort as honestly and accurately as you possibly can." Butts (1982, p. 9)

If there were any questions regarding the RPE scale they were answered prior to the initiation of the treadmill test.

<u>Heart Rate Monitoring</u>

To obtain heart rate for each subject's test, a heart rate monitoring device was used. The monitor was a Heart Watch Model 8799 distributed by Uniq Computer Instruments Corporation (CIC). The heart monitor has been validated in the study by Kline et al. (1987). This monitoring system includes a watch and a transmitter both operational by lithium batteries. The transmitter is part of a belt that is fitted around the lower chest area of the subject. The belt also contains two conductive rubber electrodes which are placed on the skin of the subjects after being moistened with tap water. The electrical activity of the heart is then transmitted from the belt to the watch which must be within 3.5 feet of the transmitter and must not be near strong electromagnetic radiation sources such as radios and televisions. The watch digitally displays the heart rate in the lower right hand corner on the screen of the watch. For the treadmill VO_2max test, the watch was placed on the handrail of the treadmill furthest from the BMMC to prevent any electrical interference, but close enough to the subject for transmission of heart rate.

Heart rate was obtained in the same way for the one-mile walk for time. The only exception was the watch was worn by each of the subjects on either wrist. Up to five subjects performed the one-mile walk at one time, but were separated to prevent interference between transmitters. Headphone radios were not worn by the subjects in order to prevent any electrical interference.

Experimental Procedure

The Human Subject Form (see Appendix C) was approved prior to testing. Volunteers signed a written informed consent (see Appendix D) before their participation in any phase of the practice or testing which explained both types of tests, risks involved, agreement of good health, and freedom of consent.

The order in which each test was performed was not specified, however, the subject performed all tests within a two week period of time with no two tests performed on the same day. Before testing an information sheet (see Appendix E) was given to each subject specifying test times and instructions to follow previous to each test. The following is an explanation of the procedures for each test.

Treadmill VO_2max Test

Test Procedure. Each subject reported to the Human Performance Laboratory, room 225, Mitchell Hall at UW-L at the specified time. If the subject was unfamiliar with VO_2max testing or treadmill running he was scheduled for a practice session prior to his test. The practice consisted of watching a treadmill VO_2max test and practicing walking and running on the treadmill as well as getting on and off the treadmill.

Before testing, the test administrator assisted each subject in determining his weight (lbs) and his height (in) with shoes off. The RPE was explained at this time. The heart rate monitor was then placed on the subject's lower chest after being moistened with tap water. The belt of the monitor was tightened to fit snugly but comfortably. In some instances the belt was taped with hypoallergenic surgical tape to ensure that the belt would not slip down during the test. The subject then placed the mouth piece in his mouth and breathed in and out to make sure the valves were not sticking together and that the mouth piece was assembled correctly. The headgear was then placed on the subject's head and tightened to fit comfortably but secure. A clip was then secured on the subject's nose so that all air exchange took place through his mouth.

The subject was asked to straddle the treadmill and the treadmill was turned on at a walking speed between 3-4 miles per hour (mph) 0% grade. The subject could step onto the treadmill when he felt comfortable to do so. Once the subject was on the treadmill and felt comfortable, the speed was then increased to 5 mph or more depending on the speed at which the subject was comfortable jogging. The BMMC was then started after programming in the subject's weight and immediate calibration of the gases. After this was completed the warm-up phase of the test began.

The protocol used for the treadmill VO_2max test was the Butts' Protocol (1982) [see Appendix F], but modified slightly for less fit or more fit persons. The protocol after the warm-up phase, kept a constant speed and increased 2.5% grade every two minutes, until the subject completed the workload at 10% grade. At that point, speed was then increased by 0.5 to 1 mph per two minute stages. The RPE was determined at the end of each stage and heart rate was recorded at the end of each minute. The BMMC was programmed to calculate gas parameters every minute. Verbal encouragement was given throughout the test, however, more encouragement was given during the last minutes of the test as determined by Respiratory Exchange Ratio (R) greater than 1.00 or RPE at 19 to 20. This was done to motivate the subject to ensure the obtainment of maximal effort. When the subject could no longer continue, he straddled the treadmill and the headgear and mouth piece was removed. The grade and speed of the treadmill were brought down to 3-4 mph, 0% grade to allow the subject to walk for cool-down and recovery.

Determination of VO_2max. Designating VO_2max for each subject was determined by the last minute ventilation interval on the BMMC and the highest value expressed as VO_2 ($ml \cdot kg^{-1} \cdot min^{-1}$ & $l \cdot min^{-1}$). Although a full minute interval was desired, no value less than 30 seconds was accepted if the subject could not continue for the full minute.

Indicators that VO_2max was achieved included a R value of 1.00 or greater, RPE of 19 or 20, achievement of age-predicted maximal heart rate (220 - age), and subject's appearance. Although all of the indicators were not present, the R value and subject's appearance were mostly used in determining if the subject did, indeed, reach maximal effort.

One-Mile Walk for Time Field Test

Test Procedures. Each subject reported to the indoor track in the UW-L fieldhouse at Mitchell Hall at the specified time. The subject was weighed (lbs) with shoes off prior to the test. The heart rate monitor was then placed around the lower chest area after being moistened with tap water. The heart monitor watch was secured on the subject's wrist and the subject was shown the appropriate way to read the watch to obtain heart rate. The subject was then instructed to walk as fast as possible without "running" for eight laps on the inner lane of the 220 yard track. The subject was instructed to call out heart rate from the screen of the watch every quarter mile or two laps.

The test began at a designated line on the track. A stop watch was started as soon as the subject began walking. A test administrator kept track of laps and requested heart rate at the appropriate times during the walk. The walk ended as soon as the subject crossed the same designated line after eight laps. Time was recorded to the one hundreth of a second. This procedure was completed twice by each subject. The instructions were repeated to remind the subjects of the test procedures.

Determination of VO_2max. To obtain VO_2max values, the time for the one-mile walk, heart rate of the last quarter mile, weight, age, and gender were computed into the following equations (Kline et al. 1987):

GENERAL

$$VO_2max\ (l \cdot min^{-1}) = 6.9652 + 0.0091*WT - 0.0257*AGE + 0.5955*SEX - 0.2240*T1 - 0.0115*HR1\text{-}4$$

$$VO_2max\ (ml \cdot kg^{-1} \cdot min^{-1}) = 132.853 - 0.0769*WT - 0.3877*AGE + 6.3150*SEX - 3.2649*T1 - 0.1565*HR1\text{-}4$$

MALE-SPECIFIC

$$VO_2max\ (l \cdot min^{-1}) = 9.0093 + 0.0106*WT - 0.0277*AGE - 0.3115*T1 - 0.0148*HR1\text{-}4$$

$$VO_2max\ (ml \cdot kg^{-1} \cdot min^{-1}) = 154.899 - 0.0947*AGE - 0.3709*AGE - 3.9744*T1 - 0.1847*HR1\text{-}4$$

The variable are represented as follows: Weight in pounds (WT), track walk-1 (T1), heart rate fourth quarter of walk-1 (HR1-4), age in years, and sex (1 = male, 0 = female). [p. 256]

The equations express VO_2max values in liters per minute ($l \cdot min^{-1}$) or relative values ($ml \cdot kg^{-1} \cdot min^{-1}$). A computer program was used to obtain predicted VO_2max values by inputting the above variables. This program was developed by Bradley Van Skyhawk especially for this study.

Statistical Treatment

Group means and standard deviations were calculated for all physical characteristics (i.e., age, height, and body weight). A dependent student's t-test was used to determine if there was a significance difference between the two, one-mile walk times and heart rate responses. A dependent student's t-test was also computed between the two walk prediction values for absolute ($l \cdot min^{-1}$) and relative ($ml \cdot kg^{-1} \cdot min^{-1}$) VO_2max. A Pearson Correlation Coefficient (r) then was used to correlate actual VO_2max to the predicted values, as well as a student's dependent t-test, for both one-mile walks. A 0.05 level of confidence was established for all statistical treatment of data.

CHAPTER IV

RESULTS AND DISCUSSION

Introduction

Walking is an exercise which has increased in popularity due to its convenience and ease, along with obtaining training heart rate levels without the incidence of injury as seen with running (Jonas & Radesky, 1988). Since the increased popularity of walking, a field prediction VO_2max test and equations have been developed by Kline et al. (1987). These equations include the variables of age, weight, gender, one-mile walk time, and heart rate responses during a one-mile walk and are based on a population between the ages of 30 to 69 years. Since the age group studied by Kline et al. (1987) included ages over 30 years, a prediction test for a slightly younger population would also be of great value. The purpose of this study was to compare VO_2max values obtained by using the Kline's et al. equations with actual VO_2max values obtained from a population of college-aged males between the ages of 18 to 29 years.

This chapter presents the results of this study which include descriptive characteristics of the subjects, performance results from both tests, and correlations between the prediction VO_2max values to actual VO_2max values.

Descriptive Characteristics

Thirty-four male university students participated in this study and their descriptive characteristics are presented in Table 2. The ages of the subjects in this study were skewed low although the age range was 18 to 29 years. The subjects' height and age were similar to subjects in other studies, but were slightly heavier (Magel et al., 1975; Glassford et al., 1965). The weights and heights in the present study, however, were similar when compared to the male subjects of the same age range in other studies (Farwell & Mayhew, 1983; Cooper, 1968; deVries & Klafs, 1965).

Table 2. Descriptive characteristics of college-age males (n = 34)

Variables	Mean	SD	Range
Age (yrs)	21.9	2.86	18-29
Height (in)	69.8	3.33	63.8-76.5
Weight (lbs)	171.43	20.25	130.50-221.50

Performance Results

Three tests were performed for this study which included two, one-mile walks using an indoor 220 yard track and heart rate monitors to obtain heart rate response (Kline et al., 1987), and one directly measured VO_2max test using a motorized treadmill and a protocol developed by Butts (1982).

Actual Maximal Oxygen Consumption Test

The responses during the treadmill VO_2max test while measuring expired gases and obtaining heart rate responses are presented in Table 3. All subjects reached maximal values as indicated by reaching age-predicted maximal heart rate and/or by achieving a respiratory exchange ratio (RER) greater than 1.0 which was obtained by measuring expired gases. There was a large range for maximal heart rate (180-226 bpm), which may indicate that age-predictions for maximal heart rate may not be appropriate for some individuals. Overall, maximal heart rate was slightly higher when compared to other studies (McConnell et al., 1984; Kline et al., 1987), but was expected since their subjects were slightly older in age. Subjects of the same age group had similar maximal heart rates (Magel et al., 1975).

Table 3. Physiological responses of college-age males during the measured VO_2max treadmill test.

Variables	Mean	SD	Range
VO_2max ($l \cdot min^{-1}$)	4.27	0.42	3.08-5.05
VO_2max ($ml \cdot kg^{-1} \cdot min^{-1}$)	55.5	6.2	41.5-68.1
V_E BTPS ($l \cdot min^{-1}$)	141.7	15.8	111.0-166.6
RERmax	1.15	0.05	1.06-1.26
HRmax (bpm)	195.5	9.0	180-226

The achieved mean RER for this study was well above 1.0 as seen with other studies (McArdle et al., 1973; Jackson & Squires, 1982). This indicates maximal effort since individuals are at an anaerobic state at or above an RER of 1.0.

Ventilation volumes for the subjects were lower when compared to subjects in the study by McArdle et al. (1973) whose subjects were slightly smaller in size. Ventilations, however, were similar to that found by Jackson and Squires (1982) for subjects comparable in size, but slightly older in age.

The relative VO_2max ($ml \cdot kg^{-1} \cdot min^{-1}$) values for the subjects indicate high cardio-respiratory fitness according to American Heart Association (1972) norms provided in Table 4. There was a wide range, however, which classified subjects' VO_2maxs as low as "average" to subjects' values well exceeding the "high" category. Overall, relative VO_2max was lower for the present subjects when compared to highly active males in studies conducted by Paliczka et al. (1987) and by Davies et al. (1984). Coleman et al. (1987), however, using the same walking study on a similar age group, resulted in similar VO_2max values in relative terms. The VO_2max results both absolute and relative values were moderately higher when compared to male Physical Education majors (deVries & Klafs, 1965) and relative values were high compared to the treadmill protocol VO_2max values obtained by Farwell and Mayhew (1983). The subjects in this study, therefore, demonstrated a higher cardio-respiratory fitness level as compared to males in other studies.

Table 4. Cardio-respiratory fitness classification for males ($ml \cdot kg^{-1} \cdot min^{-1}$).

Age	Low	Fair	Average	Good	High
20-29	<25	25-33	34-42	43-52	>53
30-39	<23	23-30	31-38	39-48	>49
40-49	<20	20-26	27-35	36-44	>45
50-59	<18	18-24	25-33	34-42	>43
60-69	<16	16-22	23-30	32-40	>40

Note. By the American Heart Association, 1972, Exercise Testing with Apparently Health Individuals: A Handbook for Physicians, p. 15.

One-Mile Walk Prediction Test

Two, one-mile walks were performed in order to determine if there was a learning effect between walk 1 and walk 2. The results of the time of each walk and heart rate responses are presented in Table 5. A dependent student's t-test indicated the walking time for the first walk was significantly ($p < 0.001$) higher than for the second walk. Heart rate response during the last quarter mile was significantly ($p < 0.001$) higher for the second walk than for the first walk. Since the time for the second walk significantly decreased, this indicated a learning effect, however, the increase in speed of walking also elicited a corresponding increase heart rates.

Table 5. Time results and heart rate responses during the two, one-mile walks.

Variables	Walk One*	Walk Two
Walk Time (min)	12.44 0.91	12.01 1.06
Heart Rate (bpm)	149.91 20.98	157.82 22.73

*p < 0.001 between walk 1 and walk 2 for all variables

The results indicate walk times in minutes for walk 1 and walk 2 were faster for the present subjects than for older males in the study by Kline et al. (1987). The slower walk times for Kline's et al. subjects was expected due to either decrease in activity or increased body fat as seen with increasing age (Heath et al. 1981). This faster walking speed, therefore, produced higher heart rate responses for walk 1 and walk 2 which were higher than the heart rate response seen in the study by Kline et al. (1987). Lower heart rate responses as seen by Kline's et al. (1987) older males may also be a response to increasing age. Himann, Cunningham, Rechnitzer, and Paterson (1988) concluded that there is a slight linear decrease in maximal heart rate with increasing age.

Provided in Table 6 are categories of cardio-respiratory fitness classifications according to walk times for males between the ages of 30 to 69 years (Rippe, Ross, et al., 1986). These categories were developed by data obtained from the same population included in the study by Kline et al. (1987). According to Table 6, the fitness classification places Kline's et al. (1987) subjects into the "low average" category as a whole. In comparison, the subjects' mean time in this study classified as "high average". This indicates a difference of cardio-respiratory classification that was earlier noted for VO_2max results (see Table 3). Since this table does not take into consideration other variables, it may not be appropriate for determining cardio-respiratory fitness.

Prediction VO_2max results using both generalized and ~~and~~ male-specific equations for absolute and relative VO_2max are presented in Table 7. The generalized equations were developed from populations

Table 6. Categories of cardio-respiratory fitness determined by walk times for males.

Category	Time (min:sec)
Excellent	≤ 10:12
Good	10:13 - 11:42
High Average	11:43 - 13:13
Low Average	13:14 - 14:44
Fair	14:45 - 16:23
Poor	≥ 16:24

Note. From, One mile walk norms for healthy adults, by Rippe, Ross, et al., 1986, Medicine and Science in Sports and Exercise, p. s21.

including both genders. Males generally have a higher VO_2max than the equally trained female (Sparling & Cureton, 1983). Sex-specific equations, therefore, are usually more accurate since the equations do not take into consideration both sexes.

Dependent student's t-test were performed and indicated no significant ($p > 0.05$) difference between the VO_2max ($l \cdot min^{-1}$ & $ml \cdot kg^{-1} \cdot min^{-1}$) prediction values using either the generalized or specific equations between the two walks.

The predicted VO_2max in both absolute and relative values with walk 1, were considerably higher when compared to Kline et al. (1987). This was expected since the population in this study was younger and included a narrower range in age than the study by Kline et al. (1987). Pollock and Gushiken (1985) suggested that there is a 9% decrease per

Table 7. Prediction VO_2max results during the two, one-mile walks along with actual VO_2max values.

	$l \cdot min^{-1}$		$ml \cdot kg^{-1} \cdot min^{-1}$	
Variable	General	Male-Specific	General	Male-Specific
Walk 1*				
	4.05	4.12	53.4	53.4
	0.27	0.35	3.7	4.3
Walk 2*				
	4.05	4.14	53.6	53.7
	0.28	0.36	4.0	4.8
Actual**				
	4.27		55.5	
	0.42		6.2	

*p = no significant ($p > 0.05$) difference between Walk 1 and Walk 2
** $p < 0.01$ between prediction to actual VO_2max values

decade in VO_2max as a result of age, however, if training intensity continues a 5% decrease per decade is assumed. This 5% decrease was hypothesized, in part, as a result of a decrease in maximal heart rate as seen with aging. The lower values presented by Kline et al. (1987) supports this finding.

A dependent student's t-test was performed between the actual and prediction VO_2max values (see Table 7). The results indicate that actual VO_2max was significantly ($p < 0.01$) higher than all walk prediction values. Coleman et al. (1987), however, found no significant difference between the actual and the prediction values using the general relative VO_2max equation.

Comparison of Maximal Oxygen Consumption

The Pearson Product Moment correlation technique was used to determine the relationship between actual to predicted VO_2max for both walks in absolute and relative values which are presented in Table 8. The results indicate a moderately high positive correlation ($p < 0.001$) in liters per minute for Walk 1 general equation and male-specific equation. Slightly lower correlations ($p < 0.001$) were found with Walk 2 general equation and male-specific equation.

For relative VO_2max values ($ml \cdot kg^{-1} \cdot min^{-1}$) high positive correlations were found between predicted and actual values for both Walk 1 general equation and male-specific equation ($p < 0.001$) as well as for Walk 2 general and male-specific equations ($p < 0.001$).

There was a high positive correlation between the two predictions tests for both absolute and relative values. This was expected since there was no significant difference ($p > 0.05$) between the two tests as determined by a dependent t-test.

These results compare closely with results obtained by Kline et al. (1987) using an older population. These results indicated correlations for absolute VO_2max to be 0.81 and 0.82 for males using general and male-specific equations, respectively. Relative values correlated for general ($r = 0.84$) and male-specific ($r = 0.84$) were slightly higher than the relative values seen with this study.

As with the present study, Coleman et al. (1987) used Kline's et al. (1987) one-mile walk prediction test to determine the test accuracy on a comparable group of male subjects (20-29 yrs). Coleman's et al. (1987) study was presented in abstract form and only provided results for the generalized

Table 8. Correlations between actual VO_2max and the two walk VO_2max prediction tests in absolute and relative values.

	$l \cdot min^{-1}$		$ml \cdot kg^{-1} \cdot min^{-1}$	
Variable	Walk 2	Actual	Walk 2	Actual
Walk 1				
General Equation	.89	.79	.90	.85
Male Equation	.88	.79	.91	.86
Walk 2				
General Equation	-	.75	-	.82
Male Equation	-	.75	-	.82

All resulted in $p < 0.001$

equation in relative terms ($ml \cdot kg^{-1} \cdot min^{-1}$). They indicated a moderately high correlation with actual VO_2max values ($r = 0.79$) for males, which was slightly lower than for the relative values obtained in this study for both walks.

Discussion

The subjects in this study were considered in the normal range when compared to similar aged males in the literature according to height and weight. Cardio-respiratory fitness was slightly higher in these subjects as compared to other subjects with respect to VO_2max, both absolute and relative values.

The results obtained from the two, one-mile walks, indicated that there was a significant difference found between walk time for both walks, as well as heart rate responses. It was noted as the subject decreased walk time for the second walk, the heart rate response increased. It was then concluded that there was an inverse relationship between heart rate response and walk time. The equations account for this response due to the fact that no significant difference in the prediction values, both relative and absolute, were found between the two tests. It was concluded that even though there was a decrease in time of walk as a result of the learning effect, the faster time corresponds with a higher heart rate resulting in no significant difference of predicted max between the two walks. On this basis, it appears that only one walk need to be performed when using any prediction VO_2max equation by Kline et al. (1987).

There was a moderately high positive correlation found between the Kline's et al. (1987) prediction equations for VO_2max and actual VO_2max. It was therefore concluded that Kline's et al. (1987) prediction equations could be used to estimate VO_2max in a younger male population of 18 to 29 years. A student's dependent t-test indicated, however, that actual VO_2max was significantly higher ($p < 0.01$) than all walking prediction VO_2max values obtained by using Kline's et al. (1987) equations. Therefore, using these prediction equations may produce slight underestimations of VO_2max.

Sex-specific equations are preferred since generally VO_2max is higher for the males than females of the same training level (Sparling & Cureton, 1983). The general equations accounts for gender differences, but the linear regression still includes data obtained both from male and female subjects, whereas sex-specific only include data obtained from that specific gender group. In the present study, the highest correlation was found between the male-specific equation and actual when expressed in relative terms. It was therefore concluded that sex-specific equations are ideal when studying a specific sex population.

A secondary purpose of this study was to develop prediction VO_2max equations if, in fact, low correlations were found between actual VO_2max values and prediction VO_2max values obtained through Kline's et al. (1987) equations. Since the values obtained in this study resulted in similar values as Kline's et al. (1987) male-specific and general equations, this portion of the study was deemed unnecessary.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The primary purpose of this study was to determine if Kline's et al. (1987) field prediction VO_2max test was valid in predicting VO_2max for college-aged males between the ages of 18 to 29 years. The secondary purpose was to develop a regression equation if, in fact, a low correlation between actual and predicted VO_2max resulted using Kline's et al. equations. This secondary purpose, however, was not addressed due to adequate correlations.

Thirty-four healthy, college males participated in this study. Each subject performed an actual treadmill VO_2max test and two, one-mile walks. The physiological parameters during the actual VO_2max test were measured which included minute ventilations (V_E, $l \cdot min^{-1}$), oxygen consumption (VO_2, $l \cdot min^{-1}$), VO_2 ($ml \cdot kg^{-1} \cdot min^{-1}$), respiratory exchange ration (RER), and heart rate. During the walks, heart rate responses were recorded every quarter mile as well as the cummulative walk time for each subject.

Statistical analyses included means, standard deviation, and ranges for the physical characteristics and performance results. A dependent student's t-test was performed between the two walks for heart rate response, walk time, and predicted VO_2max for absolute and relative values, both general and sex-specific. A dependent student's t-test was also performed between actual VO_2max values and all prediction values. A Pearson Product Moment Correlation was calculated to determine the relationship between the predicted VO_2max values and actual values both in absolute and relative terms. Significance level was set at 0.05 level of confidence for all tests.

Conclusion

Based on the results obtained from this study, the following conclusions were reached. The subjects in this study were in good health and demonstrated high cardio-respiratory fitness according to the American Heart Association (1972) norms.

Due to the significantly faster walk time for Walk 2 as compared to Walk 1, it was concluded that there was a learning effect demonstrated following the completion of the first walk. The faster walk time, however, did not produce a higher prediction VO_2max due to the increased heart rate response. This was concluded since no significant difference was found for the predicted VO_2max values between Walk 1 and Walk 2. It is, therefore, suggested that only one walk need to be performed to predict VO_2max.

A dependent student's t-test indicated that actual VO_2max values were slightly higher when compared to predicted values. This indicated a slight underestimation of VO_2max using Kline's et al. (1987) prediction equations. There was a moderately high correlation, however, found between all prediction VO_2max values when compared to actual VO_2max. These findings compare closely with the results obtained by Kline et al. (1987). It was, therefore, concluded that Kline's et al. (1987)

equations, relative and absolute, general and sex-specific, can be used to predict VO_2max in college-aged males (18 - 29 yrs). The null hypothesis which stated that there would be no correlation between prediction VO_2max values developed by Kline et al. (1987) and actual VO_2max was rejected.

The sex-specific equation for males in relative terms was found to have the highest correlation with actual VO_2max. It is recommended that this equation be used rather than the remaining equations provided by Kline et al. (1987).

Due to the moderately high correlation obtained between predicted and actual VO_2max, regression equations were not developed.

Recommendations

The following recommendations are offered based on the results of this study. Subject sample should include a wider range of fitness levels, thus making the population more heterogeneous. Randomize sampling would be ideal but would be difficult to obtain.

Before the walking test begins, it is suggested that the test administrator inform the subjects that muscles in the shin area may become painful if the subject is not acquainted with walking fast over a distance of one mile. Proper stretching techniques should be provided.

The heart rate monitor devices were secured to the subject by way of an elastic belt. This belt, however, did not fit tightly for thin subjects and may slip during the testing. For those subjects, surgical tape should be used to fasten the belt to the subject to prevent slippage of the belt.

Recommedations for future study include obtaining subjects with different percentage of body fat to determine the relationship of Kline's et al. (1987) equations with VO_2max based on fat free weight.

In addition, a training study based on speed walking is recommended to determine the differences between pre and post walking prediction tests, since the second walk was generally faster in time but elicited a lower VO_2max correlation.

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APPENDIX A

February 17, 1989

Dear

This letter is to inform you about a research study in the Adult Fitness/Cardiac Rehabilitation program. The study involves validation of a new prediction field test for ages 18-29 years of age. Both male and female subjects will be tested, but separated into two theses topics.

The prediction test is a one-mile walk for time. The equation used for prediction of VO_2max was developed by Kline et al. (1987) and was validated for ages 30 to 69 years.

The purpose of this study is to determine if the one-mile walk field test by Kline et al. (1987) accurately predicts VO_2max in the young adult population, both male and female, ranging in age between 18-29 years. This will be done by comparing actual VO_2max values from a treadmill protocol withthe predicted VO_2max values obtained during the one-mile walks and using the equation developed by Kline et al. (1987). The secondary purpose of this study is to develop a valid equation in case of low correlation of the actual to predicted VO_2max tests is found when using the above equation.

It is our understanding that in the past, PE 114 students were required to perform a VO_2max test. Since it is no longer a requirement, we would like to afford the students the opportunity to participate in this study which, as stated above, requires a VO_2max test. However, along with the VO_2max test they would also perform two, one-mile walk prediction tests.

Any questions or concerns please feel free to contact us at 783-8256.

Jane Dzaboff
Stacey Van Skyhawk

Adult Fitness/Cardiac
Rehabilitation
Graduate Students

APPENDIX B

Borg's Scale, Ratings of
Perceived Exertion (RPE)

6	
7	Very, Very Light
8	
9	Very Light
10	
11	Fairly Light
12	
13	Somewhat Hard
14	
15	Hard
16	
17	Very Hard
18	
19	Very, Very Hard
20	

(Borg, 1973, p. 92)

APPENDIX C

Application for Review of Research Proposals Involving the Use of Human Subjects

Attachment A

University of Wisconsin - La Crosse
La Crosse, Wisconsin 54601

Date: ____________________

Title of Proposed Project: ____________________

Principal Investigator/Project Director: ____________________

(Check #1 or #2 below - whichever is appropriate)

1. ☐ This application was reviewed by a departmental committee consisting of the undersigned. The committee finds that the proposal does not encompass investigations involving human subjects who may be placed at risk, including clinical research. (If the decision by the Departmental Review Committee is not unanimous, the proposed investigation must be reviewed by the Institutiona Review Board on the Use of Human Subjects.

____
Principal Investigator
(Faculty Member)

____
Committee Member

____
Department Chairperson

2. ☐ This application includes or is likely to include investigations involving human subjects who may be placed at risk, including clinical research. It is hereby certified that the procedures encompassed by this application should be reviewed by the Institutional Review Board (Use of Human Subjects) in accordance with Public Law 93-348.

____
Principal Investigator.
(Faculty member)

____
Committee Member

____
Department Chairperson

NOTES:

1. "'Subject at risk' means any individual who may be exposed to the possibility of injury, including physical, psychological, or social injury, as a consequence of participation as a subject in any research, development, or related activity which departs from the application of those established and accepted methods necessary to meet his needs, or which increases the ordinary risks of daily life, including the recognized risks inherent in a chosen occupation or field of service."

2. Signed copies of Attachment A should be distributed to the Principal Investigator, Department Chairperson, Dean of the School/College, and the Institutional Review Board Chairperson.

APPENDIX D

INFORMED CONSENT
ONE-MILE WALK VALIDATION STUDY

I, ______________________________, volunteer to be a subject in a research study to determine if the One-Mile Walk is a valid field test for predicting VO_2max in the young adult population. I understand participation in this project requires that I complete one VO_2max test on the treadmill and two, one-walks a mile on the indoor track in Mitchell Hall as fast as possible.

The actual treadmill test will consist of a series of submaximal efforts at increasing grades and/or speed until I reach maximal effort. During the VO_2max test my heart rate will be monitored continuously via ECG or heart rate monitor. Also I will breathe room air through a mouthpiece so that my exhaled air can be collected. Although this test will require a maximal effort I understand that I can stop the test anytime I wish.

The one-mile walk tests will consist of walking as fast as possible for a distance of one mile. I am aware that I will be wearing a heart monitoring device throughout the test and my heart rate will be taken at differing intervals. As with any exercise, there exists the possibility of adverse changes occurring (i.e., dizziness, difficulty in breathing, etc.) during these tests. In addition, I will probably feel tired at the end of the tests. If any abnormal observations are noted at any time the test will be immediately terminated.

At least one session will be required to become familiar with running on a treadmill and the equipment. Both the practice and testing sessions will be scheduled at my convenience. During these periods I will be given specific instructions in order to improve my techniques. The tests and practice sessions will be supervised/conducted by Jane Dzaboff, R.N. and Stacey Van Skyhawk, under the supervision of N.K. Butts, Ph.D.

I consider myself to be in good health and to my knowledge I do not have any limiting physical condition or disability, especially with respect to my heart, that would preclude my participation in the exercise tests as described above. I have read the foregoing and I understand what is expected from me. Any questions which may have occurred to me have been answered to my complete satisfaction. I, therefore, voluntarily consent to be a subject in this study. Furthermore, I know I may withdraw at any time without any type of penalty.

Signed: ____ Date: ______________

Witness: _______________________________________ Date: ______________

APPENDIX E

Test Information Form

Name ______________________________

Your VO_2max test is scheduled for ______________________________

Your practice time is scheduled for ______________________________

Your One-Mile Walks are scheduled for ____________/____________

The VO_2max test will be conducted in the Human Performance Laboratory (room225) in Mitchell Hall.

The One-Mile Walk tests will be performed on the indoor track in Mitchell Hall.

The tests you will be performing can give you a very accurate idea of your cardiorespiratory fitness level. Thus, you will be able to evaluate the effectiveness of your current exercise program or the results may give you the motivation to start one!! Due to the nature of the test, special preparation is required of you. Listed below are the responsibilities you have to meet in order to make your assessment the best possible.

1. Do not eat, smoke or ingest alcoholic or caffeinated beverages for four hours prior to the testing time.

2. Do not exercise on the same day of the test prior to being tested.

3. Wear a t-shirt and shorts/sweats with comfortable walking or running shoes for the testing.

4. Be sure to warm-up and stretch before testing. If you are unfamiliar with the proper stretching techniques, ask the test administrators for assistance.

5. If unable to attend a scheduled time, please contact Jane Dzaboff at 783-8256 or Stacey Van Skyhawk at 784-5151 or leave a message at the Human Performance Laboratory - 785-8685 (24 hours prior to testing if possible).

Thank you for volunteering to be part of our research study. We look forward to seeing you soon!

APPENDIX F

NAME: ______ DATE: ______ TIME: ______ TEMP ______ Pbar ______

______ lbs ______ kg ______ %fat ______ LBW ______ Height ______ age ______ birthdate ______ miles/wk

	WORKLOAD	$\dot{V}_E$	ml O_2	ml·kg	$\dot{V}_{CO_2}$	RER	$FeCO_2$	FeO_2	HR	RPE	ml·LBW
(1)	5 mph 0										
(2)	5 mph 0										
(3)	5 mph 0										
(4)	5 mph 0										
(5)	5 mph 0										
(6)	6 mph 2½										
(7)	6 mph 2½										
(8)	6 mph 5										
(9)	6 mph 5										
(10)	6 mph 7½										
(11)	6 mph 7½										
(12)	6 mph 10										
(13)	6 mph 10										
(14)	6½mph 10										
(15)	6½mph 10										
(16)	7 mph 10										
(17)	7 mph 10										
(18)	7½mph 10										
(19)	7½mph 10										
(20)	8 mph 10										
			O_2								
			CO_2								

APPENDIX G

Raw Data from the Two, One-Mile Walks

Ss	Walk No.	Age	WT (lbs)	HR (bpm)	Time (min:sec)	VO_2max^a	VO_2max^b	VO_2max^c	VO_2max^d
1	1	20	180.0	142	12:25	4.27	4.39	54.8	54.9
	2		182.0	150	11:23	4.43	4.61	56.8	57.3
2	1	26	224.0	154	11:45	4.53	4.72	49.4	48.9
	2		223.0	168	10:57	4.53	4.76	49.9	49.6
3	1	21	179.0	177	11:10	4.11	4.23	53.1	53.1
	2		179.0	185	10:57	4.07	4.18	52.6	52.5
4	1	21	155.5	106	12:11	4.49	4.72	62.7	64.3
	2		153.0	126	11:34	4.37	4.58	61.8	63.4
5	1	20	127.0	168	10:48	3.85	3.95	60.1	61.5
	2		129.0	156	09:54	4.21	4.43	64.8	67.1
6	1	28	164.0	160	13:33	3.46	3.38	46.4	45.6
	2		165.0	168	12:46	3.55	3.52	47.7	47.1
7	1	19	178.0	171	12:13	3.99	4.03	51.5	50.9
	2		175.0	182	12:10	3.85	3.85	50.1	49.3
8	1	19	155.5	148	12:11	4.06	4.15	56.7	57.3
	2		157.5	156	11:39	4.11	4.22	57.2	57.8
9	1	23	180.0	157	11:46	4.17	4.29	53.4	53.6
	2		184.0	178	11:13	4.08	4.19	51.6	51.5
10	1	20	155.0	144	12:03	4.10	4.21	57.6	58.3
	2		153.0	184	11:14	3.81	3.85	54.2	54.4
11	1	20	179.0	183	10:52	4.14	4.26	53.5	53.5
	2		180.0	182	10:07	4.33	4.52	56.1	56.6
12	1	20	187.0	162	11:34	4.29	4.44	53.9	53.9
	2		187.0	179	11:04	4.21	4.34	52.9	52.7
13	1	21	171.0	131	12:47	4.21	4.32	55.6	55.9
	2		173.0	160	11:50	4.10	4.21	54.0	54.1
14	1	23	156.0	142	12:11	4.03	4.13	56.3	56.9
	2		158.5	128	12:22	4.17	4.31	57.6	58.5
15	1	20	148.0	173	11:31	3.82	3.87	55.3	55.7
	2		146.0	172	10:41	4.00	4.13	58.4	59.4
16	1	22	168.0	118	12:57	4.27	4.40	57.0	57.6
	2		164.0	117	12:48	4.27	4.41	57.9	58.7
17	1	22	199.5	161	13:08	4.02	4.05	47.2	45.9
	2		195.0	174	12:36	3.94	3.96	47.2	46.0

[a] VO_2max ($l \cdot min^{-1}$) General Equation
[b] VO_2max ($l \cdot min^{-1}$) Male-Specific Equation
[c] VO_2max ($ml \cdot kg^{-1} \cdot min^{-1}$) General Equation
[d] VO_2max ($ml \cdot kg^{-1} \cdot min^{-1}$) Male-Specific Equation
(Kline et al., 1987)

Ss	Walk No.	Age	WT (lbs)	HT (in)	Time (min:sec)	VO_2 max[a]	VO_2 max[b]	VO_2 max[c]	VO_2 max[d]
18	1	21	180.0	150	11:59	4.25	4.38	54.6	54.7
	2		181.0	157	11:13	4.35	4.53	55.9	56.4
19	1	27	142.0	137	12:30	3.78	3.85	55.5	56.5
	2		144.0	143	12:38	3.03	3.74	54.0	54.6
20	1	23	162.0	168	11:53	3.85	3.90	52.7	52.8
	2		160.0	159	12:49	3.73	3.72	51.2	50.9
21	1	22	194.0	172	12:52	3.90	3.90	46.8	45.5
	2		200.0	167	12:34	4.08	4.13	48.0	46.9
22	1	23	149.0	167	11:49	3.76	3.80	54.1	54.4
	2		146.0	178	10:59	3.79	3.86	55.3	56.0
23	1	19	163.0	139	14:35	3.69	3.61	49.9	48.8
	2		163.0	127	14:57	3.75	3.67	50.6	49.5
24	1	25	165.0	121	14:01	3.89	3.91	52.1	51.9
	2		167.0	121	13:40	3.99	4.04	53.1	53.1
25	1	27	183.5	181	11:55	3.79	3.82	47.3	46.7
	2		178.0	194	11:16	3.73	3.77	47.9	47.4
26	1	20	170.0	132	13:28	4.06	4.11	53.7	53.5
	2		168.0	144	12:37	4.09	4.17	54.8	54.8
27	1	18	173.0	176	13:09	3.70	3.64	48.4	47.1
	2		172.0	182	12:41	3.73	3.69	49.1	47.9
28	1	18	190.0	160	12:07	4.27	4.38	53.0	52.5
	2		191.0	158	12.07	4.31	4.42	53.2	52.8
29	1	21	144.0	133	13:24	3.80	3.81	55.4	55.7
	2		139.0	140	13:16	3.70	3.70	55.1	55.4
30	1	25	208.0	108	13:28	4.55	4.73	52.6	52.5
	2		208.0	108	13:18	4.59	4.78	53.2	53.1
31	1	20	168.0	169	11:57	4.12	4.22	55.2	55.4
	2		169.0	165	11:38	4.08	4.18	54.6	54.8
32	1	21	202.0	142	11:30	4.65	4.89	55.7	56.0
	2		202.0	154	11:40	4.47	4.66	53.3	53.2
33	1	21	169.0	140	13:41	3.88	3.88	51.4	50.9
	2		172.0	177	12:46	3.69	3.65	48.4	47.4
34	1	29	152.0	119	13:29	3.81	3.86	53.6	54.2
	2		150.5	127	12:52	3.85	3.92	54.4	55.2

[a] VO_2max ($l \cdot min^{-1}$) General Equation
[b] VO_2max ($l \cdot min^{-1}$) Male-Specific Equation
[c] VO_2max ($ml \cdot kg^{-1} \cdot min^{-1}$) General Equation
[d] VO_2max ($ml \cdot kg^{-1} \cdot min^{-1}$) Male-Specific Equation
(Kline et al., 1987)

Raw Data from Actual VO_2max Test

Ss	V_E ($l \cdot min^{-1}$)	VO_2 ($l \cdot min^{-1}$)	VO_2 ($ml \cdot kg^{-1} \cdot min^{-1}$)	RER	HR (bpm)	WT (lbs)	HT (in)
1	161.29	5.05	61.1	1.12	190	182.0	72.50
2	159.57	5.05	50.3	1.06	186	221.5	75.00
3	160.02	4.69	57.9	1.10	205	178.5	76.00
4	157.53	4.56	65.2	1.26	187	154.0	67.75
5	139.34	4.03	68.1	1.19	197	130.5	63.75
6	113.06	3.08	41.5	1.19	186	164.0	68.00
7	140.52	4.09	51.8	1.14	192	174.0	72.50
8	132.55	4.17	58.7	1.11	194	156.5	69.25
9	125.40	4.44	53.7	1.10	198	182.0	74.00
10	118.70	3.91	56.1	1.15	198	153.5	65.25
11	157.41	4.53	56.1	1.20	194	178.0	68.00
12	152.46	4.53	54.9	1.17	196	182.0	75.00
13	143.84	5.03	63.4	1.19	214	175.0	69.00
14	159.67	4.29	61.6	1.11	183	153.5	69.00
15	133.78	4.03	59.3	1.13	197	150.0	71.00
16	132.48	4.34	58.1	1.14	193	165.0	67.50
17	137.92	3.92	43.9	1.20	192	197.0	67.50
18	141.12	4.51	54.7	1.13	196	182.0	71.50
19	142.85	4.25	63.7	1.05	185	147.0	67.50
20	136.64	4.03	55.2	1.19	193	161.0	66.50
21	145.04	3.96	42.4	1.13	200	206.0	71.00
22	158.89	4.04	59.3	1.19	206	150.0	68.25
23	111.00	4.04	54.3	1.07	196	164.0	66.00
24	160.44	4.58	59.7	1.18	180	169.0	67.25
25	138.51	4.02	48.3	1.13	199	183.5	65.00
26	151.07	4.18	54.5	1.26	202	169.0	70.00
27	127.61	3.77	49.1	1.15	202	172.0	68.50
28	161.01	4.73	55.1	1.14	187	189.5	73.00
29	118.92	3.83	59.3	1.11	197	142.5	69.50
30	138.62	4.32	45.5	1.23	180	209.5	74.00
31	132.92	4.33	57.2	1.10	197	167.0	71.25
32	166.62	4.97	54.8	1.16	195	200.0	76.50
33	147.22	4.02	52.9	1.14	226	167.5	69.25
34	113.42	3.99	57.9	1.14	194	152.0	66.00