ABSTRACT

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The purpose of this study was to determine the validity of the predicted maximal MET equations on the Schwinn Air-Dyne bicycle ergometer for a population of females between the ages of 19 and 29 years. Twenty-five female Ss volunteered to take part in the study. Twenty-one of the 25 Ss reached a VO_2 max (l/min) that was defined by 1 of 2 criteria for a "true" maximal test. Predicted maximal METs were compared to measured maximal METs obtained while exercising on the Schwinn Air-Dyne. Two heart rates were obtained during an 8-minute submaximal test. Predicted maximal METs were determined for each subject in an equation that used an age predicted maximal heart rate and the two submaximal heart rates. The "true" VO_2 max test was used to determine measured maximal METs. A Pearson product-moment correlation and paired t-test revealed a high positive correlation ($r = .88$) and a significant difference between the means of predicted maximal METs and measured maximal METs ($p < .05$). The difference between the means of predicted and measured maximal METs was 4.6%. Predicted maximal METs underestimated measured maximal METs by 0.56 METs. The predicted maximal MET equations were therefore considered to be valid for determining maximal METs for purposes other than research.

VALIDATION OF THE MAXIMAL MET PREDICTION EQUATIONS ON THE SCHWINN AIR-DYNE

A THESIS PRESENTED

TO

THE GRADUATE FACULTY

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CHAPTER I

INTRODUCTION

Background

The capacity for cardiorespiratory endurance or aerobic fitness has been described best by maximal oxygen consumption. Many studies have been performed on a treadmill and bicycle ergometer to assess maximal oxygen consumption (Costa et al., 1989; Hermansen & Saltin, 1969; Miyamura & Honda, 1972). Comparisons have also been made using the rowing ergometer (Mahler, Andrea, & Ward, 1987; Szal & Schoene, 1989). These may be good for assessment of an athlete's training progress, but a maximal exercise test could be unhealthy and life threatening for other individuals. Maximal exercise tests have the risk of discomfort, soreness, and dizziness. In rare instances, heart attack, stroke, or death may result. Inability to keep up with the speed of a treadmill (Mc Neill, 1981), an uncomfortable mouthpiece, or the onset of fatigue could affect maximal oxygen consumption. Therefore, a submaximal exercise test not involving discomfort and minimizing health risks would be advantageous.

A submaximal exercise test protocol and equations for predicting maximal METs were included in the Schwinn Air-Dyne bicycle owner's manual (Schwinn Bicycle Company, 1988) and Schwinn Air-Dyne Aerobic Fitness Appraisal Kit developed by Nagle (1988b). The aerobic fitness test and equations developed by Nagle (1988a) were received by this researcher in an unpublished manuscript.

The fitness level or maximal MET prediction equations utilize age predicted maximal heart rate and two submaximal heart rates. To perform the test, two workloads from Part A are chosen according to a person's weight (see Table 1). The person pedals continuously for 8 minutes: 4 minutes at the first workload and 4 minutes at the second workload. In the last 30 seconds of the fourth minute a heart rate (heart rate 1) is recorded in beats per minute (bpm). In the last 30 seconds of the eighth minute a second heart rate (heart rate 2) is recorded. Maximal heart rate (max. heart rate) is computed as 220 - age. The heart rate values are utilized in the equation to predict an aerobic fitness level or maximal METs.

$$\text{Predicted Maximal METs} = \frac{3(\text{max. heart rate}) + 3(\text{heart rate 2}) - 6(\text{heart rate 1})}{(\text{heart rate 2}) - (\text{heart rate 1})}$$

In the event the first heart rate (heart rate 1) recorded does not reach 120 bpm, an accelerated fitness test is executed. Two workloads from Part B are chosen according to the person's weight (see Table 1). The person pedals continuously for 8 minutes: 4 minutes at the first workload and 4 minutes at the second workload. Heart rates are recorded in the last 30 seconds of the fourth minute (heart rate 1) and the last 30 seconds of the eighth minute (heart rate 2). Maximal heart rate (max. heart rate) is computed as 205 - (1/2 * age). Nagle suggested for better trained, older individuals, that maximal heart rate formula provided a better estimate of maximal heart rate. An aerobic fitness level or predicted maximal METs is calculated by the equation:

$$\text{Predicted Maximal METs} = \frac{3.6(\text{max. heart rate}) + 4.8(\text{heart rate 2}) - 8.4(\text{heart rate 1})}{(\text{heart rate 2}) - (\text{heart rate 1})}$$

Table 1. Air-Dyne load settings for aerobic fitness assessments

Weight Category (Lbs.)	(Kg.)	Part A Workload Level 1st	2nd	Part B Workload Level 1st	2nd
99	45	0.5	1.3	1.0	1.9
103	47	0.5	1.4	1.1	2.0
108	49	0.6	1.4	1.1	2.1
112	51	0.6	1.5	1.1	2.2
117	53	0.6	1.5	1.2	2.3
121	55	0.7	1.6	1.2	2.4
125	57	0.7	1.7	1.3	2.5
130	59	0.7	1.7	1.3	2.6
134	61	0.7	1.8	1.4	2.7
139	63	0.8	1.8	1.4	2.7
143	65	0.8	1.9	1.4	2.8
147	67	0.8	1.9	1.5	2.9
152	69	0.8	2.0	1.5	3.0
156	71	0.8	2.1	1.6	3.1
161	73	0.9	2.2	1.6	3.2
165	75	0.9	2.2	1.7	3.3
169	77	0.9	2.3	1.7	3.3
174	79	0.9	2.3	1.8	3.4
178	81	1.0	2.4	1.8	3.5
183	83	1.0	2.5	1.8	3.6
187	85	1.0	2.5	1.9	3.7
191	87	1.0	2.6	1.9	3.8
196	89	1.1	2.6	2.0	3.8
200	91	1.1	2.7	2.0	3.9
205	93	1.1	2.7	2.1	4.0
209	95	1.1	2.8	2.1	4.1
213	97	1.2	2.8	2.2	4.2
218	99	1.2	2.9	2.2	4.3
222	101	1.2	2.9	2.2	4.3
227	103	1.2	3.0	2.3	4.4
231	105	1.3	3.0	2.3	4.5
235	107	1.3	3.1	2.4	4.6
240	109	1.3	3.1	2.4	4.7

Note: Nagle, 1988b, Schwinn Air-Dyne aerobic fitness appraisal kit, pp. 2, 4.

Advantages of this test include ease of test administration, time efficiency, and low risk to subjects. The test does not need elaborate equipment and personnel and can be performed easily at a health club or at home. An exercise prescription can be prescribed for a fitness program using the predicted maximal METs (American College of Sports Medicine, 1991).

Need for the Study

Exercise tests are often performed for developing an individual exercise prescription. The exercise prescription is used by the individual to exercise at an appropriate intensity. To have a maximal exercise test completed on a bicycle ergometer or treadmill, an individual would have to invest in a health clinic or exercise program which has the required equipment for oxygen consumption measurement. Not all facilities can afford such equipment and the exercise test may not be economically feasible for the individual. Within the last few years, the public has been made aware of health promotion and fitness. They need an economically feasible and nonthreatening way of exercising and assessing their fitness.

The Schwinn Air-Dyne Aerobic Fitness Test may be the answer. Many health clubs and exercise programs provide the Air-Dyne. Also, a person may choose to purchase a Schwinn Air-Dyne. The aerobic fitness test and maximal MET prediction equation is included in the owner's manual (Schwinn Bicycle Company, 1988). Due to the fact that this test and equations are found in the manual gives reason for determining its accuracy in predicting maximal METs.

The equation was developed on a sample of 51 subjects, however only 9 were of the female gender. Forty-two of the subjects, 38 males and 4 females, were firefighters. Firefighting requires metabolic energy requirements of 12 to 14 METs (Nagle, 1988b). The population using the

Air-Dyne at a health club or at home may not have these high energy requirements. The present study included only females, thereby creating a generalized population to give a better idea of the prediction of maximal METs for other populations.

Purpose of the Study

The purpose of the study was to determine the validity of the maximal MET prediction equations on the Schwinn Air-Dyne bicycle ergometer for predicting maximal METs in a female population between the ages of 19 and 29 years.

Hypotheses

The following hypotheses were tested:

1. There will be a high positive correlation ($r > .80$) between predicted maximal METs and measured maximal METs.
2. There will be no significant difference between the means of predicted maximal METs and measured maximal METs.

Basic Assumptions

1. All subjects exerted maximal effort during the maximal oxygen consumption bicycle test as determined by criteria set for a "true" maximal $\dot{V}O_2$.
2. All equipment was accurately calibrated and functioned properly.
3. Subjects were healthy and free of injuries as determined by a medical history form.

Delimitations

The study was delimited to females between the ages of 19 and 29 years.

Limitations

The sample was limited to nonsedentary females who were willing to volunteer to participate in the study and therefore, were not randomly chosen.

Definition of Terms

Maximal Heart Rate - the maximum number of times the heart can beat in 1 minute, which can be measured directly or estimated from the age predicted maximal heart rate formula (220 - age) (Wilmore & Costill, 1988).

Maximal Oxygen Consumption ($\dot{V}O_2$ max) - the maximum amount of oxygen which an individual can transport and utilize in 1 minute while performing an exercise to exhaustion (Brooks & Fahey, 1984).

MET - A multiple of the resting rate of oxygen consumption. One MET = 3.5 ml/kg/min (American College of Sports Medicine, 1991).

Pearson Product-Moment Correlation Coefficient (r) - a number between +1 and -1 that describes the relationship between pairs of quantitative variables (Witte, 1989).

Respiratory Exchange Ratio (RER) - the ratio of carbon dioxide expired to oxygen consumed (American College of Sports Medicine, 1988).

Standard Error of the Estimate - a rough measure of the average amount of predictive error (Witte, 1989).

UNIQ CIC Heart Watch - an exercise computer that senses the electrical signals generated by the heart, and electronically computes and digitally displays the heart rate in bpm on a watch display (Polar Electro Oy, 1989).

CHAPTER II

REVIEW OF RELATED LITERATURE

Introduction

Cardiorespiratory endurance or aerobic fitness level is often determined through results of an exercise test. The best measure of cardiorespiratory endurance or fitness level is maximal oxygen consumption (Bonen, Heyward, Cureton, Boileau, & Massey, 1979; Egger & Finch, 1988; Fox, 1973; Hermiston & Faulkner, 1971; Johnson, Oliver, & Terry, 1979; Kline et al., 1987; Pollock & Wilmore, 1990; Taylor, Buskirk, & Henschel, 1955). Maximal oxygen consumption, the maximum amount of oxygen that can be taken up and utilized by the body per unit time, is dependent on physiological mechanisms such as pulmonary ventilation, capillary diffusion, regional blood flow distribution, stroke volume, heart rate, and cardiac output (Knuttgen, 1969; McConnell, 1988). Measurement of maximal oxygen consumption is time consuming, expensive, and requires elaborate equipment and qualified personnel to conduct the testing. Sometimes it is inconvenient or unhealthy for an individual to complete a maximal oxygen consumption ($\dot{V}O_2$ max) test. A submaximal test may then be used for the prediction of $\dot{V}O_2$ max. Many researchers have developed such tests and equations to predict $\dot{V}O_2$ max (Bonen et al., 1979; Egger & Finch, 1988; Fox, 1973; Hermiston & Faulkner, 1971; Jette', Campbell, Mongeon, & Routhier, 1976; Kline et al., 1987; Nagle, 1988a; Town & Golding, 1979; Weltman et al., 1987; Wilmore et al., 1985).

Prediction Equations

There are many equations that predict VO_2 max using various physiological parameters obtained during submaximal exercise. This section will review prediction equations of different protocols and modes of exercising.

Walking

Kline et al (1987) developed a regression equation that predicts $\dot{V}O_2$ max from a 1-mile track walk. He compared predicted $\dot{V}O_2$ max to the $\dot{V}O_2$ max values of a treadmill test in 174 adults, 30 to 69 years of age. The subjects performed at least two, 1-mile walks and were instructed to walk as fast as possible. The variables used in the equation were age, weight, sex, 1-mile walk time, and heart rate during the fourth quarter mile. The equation developed to predict $\dot{V}O_2$ max was:

$\dot{V}O_2$ max (l/min) = 6.9652 + [0.0091 * weight (kg)] - [0.0257 * age (years)] + [0.5955 * sex (0=female, 1=male)] - [0.2240 * one-mile walk time] - [0.0115 * heart rate (bpm)].

The correlation coefficient for the prediction equation was $r = .93$, while the standard error of estimate was 0.325 l/min.

Hermiston and Faulkner (1971) developed regression equations to predict maximal oxygen uptake for physically active and inactive men. The stepwise regression procedures were performed on data collected on 60 men from 20 to 62 years of age. The authors made direct measurements of heart rate, ventilation, expired gas, respiratory exchange ratio, and tidal volume on each subject while performing a continuous treadmill walk test. The parameters used in the equations were age, fat-free weight (FFW), heart rate, fraction of carbon dioxide in expired gas (F_ECO_2), tidal volume in the second and ninth minute of a submaximum work level (VT_2 and VT_9), and respiratory exchange ratio (RER). The regression equations developed to predict $\dot{V}O_2$ max were:

Active men: $\dot{V}O_2$ max (l/min) = 2.966 - [0.031 * age (years)] + [0.026 * FFW (kg)] - [0.013 * heart rate (bpm)] + [25.4 * F_ECO_2] + [0.330 * VT_2] - [8.77 * RER change].

Inactive men: $\dot{V}O_2$ max (l/min) = 3.619 - [0.022 * age (years)] - [0.033 * FFW (kg)] - [2.587 * RER] + [0.253 * VT_9].

The correlation coefficient was r = .90 between the observed and predicted maximal oxygen uptake. The t-test showed that there was no significant difference between the observed and predicted mean values for the active and inactive groups.

Bonen et al. (1979) found that maximal oxygen consumption prediction equations are inaccurate predictors of $\dot{V}O_2$ max in children. They developed equations to predict maximal oxygen uptake in boys ages 7 to 15 years. Submaximal exercise variables and physical growth measurements were obtained on 100 boys. A number of regression equations were obtained, however an objective of this study was to develop $\dot{V}O_2$ max equations for use outside the laboratory. The following prediction equations were obtained when Bonen et al. (1979) used the subject's height, weight, and age:

$\dot{V}O_2$ max (l/min) = [0.051 * age (years)] + [0.014 * height (cm)] + [0.023 * weight (kg)] - 1.543.

$\dot{V}O_2$ max (ml/kg/min) = [1.341 * age (years)] + [0.248 * height (cm)] - [0.522 * weight (kg)] + 17.84.

Maximal oxygen consumption was determined with a continuous, progressive grade-incremented treadmill test. The correlation coefficients for l/min (r = .94) and ml/kg/min (r = .52) were quite different, however their errors of estimation, ±9.7% and ±9.2% respectively, were similar. Town and Golding (1977) developed a predicted maximal oxygen uptake equation for a 9 to 11 minute treadmill walking test. The study was conducted on 20 healthy adult males, age 30 to 50, who performed three progressive workloads. The most accurate prediction equation includes the parameters age, percent grade at workload three (% $grade_3$), weight, and heart rates at workload one and three (WL_1 and WL_3). The predicted $\dot{V}O_2$ max equation was:

$\dot{V}O_2$ max (ml/kg/min) = 83.0370 - [0.7094 * age (years)] + [2.4596 * % $grade_3$] - [0.1063 * weight (kg)] - [0.3317 * heart rate (WL_3)] + [0.2425 * heart rate (WL_1)].

The multiple correlation coefficient was r = .8377 with the standard error of the estimate at ±4.0795 ml/kg/min. This equation predicts $\dot{V}O_2$ max within a 9% error.

Running

Weltman et al (1987) predicted VO_2 peak from a 3200 m run. Twenty-nine subjects (approximate mean age 31.3 ± 8.3 years) had their $\dot{V}O_2$ peak predicted from a 3200 m time trial compared to the VO_2 peak measured during a continuous, running treadmill test. The equation for the prediction was:

$\dot{V}O_2$ peak (ml/kg/min) = 118.4 - [4.770 * 3200 m time (min)].

The correlation coefficient was r = .73, however the mean differences between actual and predicted values were not significantly different. The standard error of the estimate was ±4.51 ml/kg/min, a ±7.0% error.

Wilmore et al. (1985) developed a VO_2 max prediction equation from submaximal treadmill exercise using rating of perceived exertion. Eighteen men and 24 women, 18 to 30 years of age, completed a four-stage submaximal test with the speed increased by 1.0 mph for each stage while the grade remained level. The maximal test continued after the fourth stage of the submaximal test where the speed remained constant and the grade was increased 2.5% each minute until the point of volitional exhaustion. The equation used for the prediction of VO_2 max was:

VO_2 max (ml/kg/min) = 29.7 + [6.65 * TMS_3] - [0.15 * heart rate (bpm)] + [0.32 * RPE].

The subject's speed during the third stage of the test is defined in the equation as TMS_3. Heart rate and RPE represent values recorded at the end of the third minute of the third stage. The correlation result was r = .76 and the standard error of the estimate was 5.0 ml/kg/min, which is within an error of 10%.

<u>Bike Ergometry</u>

In an unpublished manuscript, Nagle (1988a) reported an aerobic fitness test and maximal MET prediction equations on the Schwinn Air-Dyne bicycle ergometer. The equation developed to predict maximal METs was:

$$\text{Predicted Maximal METs} = \frac{3.6(\text{max. heart rate}) + 4.8(\text{heart rate 2}) - 8.4(\text{heart rate 1})}{(\text{heart rate 2}) - (\text{heart rate 1})}$$

where maximal heart rate was computed as 205 - (1/2 * age). Two submaximal heart rates were recorded during the test at two workloads and computed in the equation as heart rate 1 and heart rate 2. Another predicted maximal MET equation was developed for more sedentary individuals.

$$\text{Predicted Maximal METs} = \frac{3(\text{max. heart rate}) + 3(\text{heart rate 2}) - 6(\text{heart rate 1})}{(\text{heart rate 2}) - (\text{heart rate 1})}$$

The testing was similar but maximal heart rate was computed as 220 - age.

In his study, Nagle (1988a) compared measured VO_2 max values (ml/kg/min) of 51 subjects, 42 males and 9 females, to $\dot{V}O_2$ max predicted by 1) measured maximal heart rate, 2) predicted maximal heart rate of 220 - age, and 3) predicted maximal heart rate of 205 - (1/2 * age). The subjects performed a graded exercise test on the Air-Dyne ergometer at workloads demanding 4.8 METs, 8.4 METs, 12 METs, and then subjects pedaled the ergometer with increased loads to volitional fatigue. The 4.8, 8.4, and 12 MET loads were performed for 4 minutes each. During the tests, the $\dot{V}O_2$ was measured each minute with the 4th, 8th, and 12th minute values representing the oxygen requirements of the specified workloads. The results of the study showed a correlation between measured $\dot{V}O_2$ max values and $\dot{V}O_2$ max predicted by measured maximal heart rate as .742. A correlation of .737 was found for the comparison between measured $\dot{V}O_2$ max and $\dot{V}O_2$ max predicted from the predicted maximal heart rate of 220 - age. A correlation of .690 was found for the comparison between measured $\dot{V}O_2$ max and $\dot{V}O_2$ max predicted from the predicted maximal heart rate of 205 - (1/2 * age). The prediction of $\dot{V}O_2$ max was underestimated by 12% using the measured maximal heart rate, 13% using the predicted maximal heart rate of 220 - age, and 11% using the predicted maximal heart rate of 205 - (1/2 * age).

Mastropaolo (1970) considered multiple regression equations that predict $\dot{V}O_2$ max to be more accurate than a prediction equation of a single parameter. He studied the following parameters: work rate (kpm/min), heart rate, systolic blood pressure, diastolic blood pressure, expired carbon dioxide (F_ECO_2), expired oxygen (F_EO_2), ventilation ($\dot{V}_E$), oxygen consumption ($\dot{V}O_2$), carbon dioxide production

($\dot{V}CO_2$), and respiratory exchange ratio (RER) on a Monark bicycle to derive the best prediction of $\dot{V}O_2$ max for middle-aged males. The subjects in the study were 13 men, 43 to 61 years of age. The following multiple regression equation was developed:

$\dot{V}O_2$ max (l/min) = 14.703 - [4.909 * RER] - [0.008 * work rate (kpm/min)] - [0.004 * diastolic blood pressure (mm Hg)] + [0.018 * V_E] - [16.083 * F_EO_2].

The best prediction equation was obtained at 600 kpm/min. The correlation coefficient was r = .93 and the standard error of the estimate was 0.172 l/min.

Fox (1973) developed an equation for predicting maximal aerobic power on 87 healthy, untrained college males. The prediction of $\dot{V}O_2$ max was based on the relationship between measured $\dot{V}O_2$ max and the submaximal heart rate recorded during the fifth minute of bicycle exercise at 150 watts. The equation developed was:

$\dot{V}O_2$ max (l/min) = 6300 - [19.26 * heart rate (bpm)].

The correlation coefficient was r = .76 and the standard error of estimate was 0.246 l/min or ±7.8%.

Arm Ergometry

Egger and Finch (1988) developed a multiple regression equation to predict $\dot{V}O_2$ max from a submaximal arm ergometry test. The arm ergometry test was compared to a Bruce protocol treadmill test performed by 22 college males, 18 to 25 years of age. The following prediction equation used the parameters age, body weight, exercise heart rate, and friction workload from the arm ergometry test:

$\dot{V}O_2$ max (l/min) = 4.727 - [0.0275 * age (years)] + [0.0016 * weight (kg)] - [0.0135 * heart rate (bpm)] + [0.00192 * workload (kpm/min)].

The workload and heart rate were recorded in the last 30 seconds of a 2.5 minute stage that elicited a heart rate of less than 170 bpm. The correlation coefficient between measured and predicted $\dot{V}O_2$ max was $r = .58$ and the standard error of estimation was 0.34 l/min, which is an accuracy of $\pm 9.4\%$ in predicting $\dot{V}O_2$ max.

Step Tests

Jette' et al. (1976) developed a regression equation to predict $\dot{V}O_2$ max using the Canadian Home Fitness Test (CHFT). The CHFT is a step test that utilizes double 20-cm steps. Fifty-nine subjects, 15 to 74 years of age, underwent the fitness test and a progressive walking treadmill test. After the subject completed the stage or stages of the CHFT test in his age category, heart rate was measured during the 5- to 15-second postexercise period. The parameters $\dot{V}O_2$ (l/min), postexercise heart rate, weight, and age were used in the following equation to predict $\dot{V}O_2$ max:

$$\dot{V}O_2 \text{ max (ml/kg/min)} = 42.5 + [16.6 * \dot{V}O_2 \text{ (l/min)}] - [0.12 * \text{weight (kg)}] - [0.12 * \text{heart rate (bpm)}] - [0.24 * \text{age (years)}].$$

The correlation coefficient for the equation was $r = .905$ and the standard error of measurement was 4.08 ml/kg/min. The results of a paired t-test showed that the difference between the predicted and measured $\dot{V}O_2$ max was not significant.

Summary

The preceding review of related literature has shown that $\dot{V}O_2$ max has been studied for years and is used as the best measure of cardiorespiratory endurance or aerobic fitness (Bonen et al., 1979; Egger & Finch, 1988; Fox, 1973; Hermiston & Faulkner, 1971; Johnson et al., 1979; Kline et al., 1987; Pollock & Wilmore, 1990; Taylor et al., 1955). However, maximal exercise testing is time consuming, expensive, requires elaborate equipment and qualified personnel, and may be risky, inconvenient, or unhealthy for the individual performing the test.

For these reasons, VO_2 max prediction equations have been developed and utilized. Advantages of submaximal exercise tests used for VO_2 max prediction equations are the ease of test administration, time efficiency, and that the test is less strenuous for the individual.

In this chapter, VO_2 max prediction equations using five submaximal exercise modalities (walking, running, cycle ergometry, arm cranking, and bench stepping) have been discussed. This study attempted to determine the validity of the maximal MET prediction equations on the Schwinn Air-Dyne bicycle ergometer (Nagle, 1988a, 1988b) in a population of females ages 19 to 29 years.

CHAPTER III

METHODS

Introduction

The purpose of this study was to determine the validity of the maximal MET prediction equations on the Schwinn Air-Dyne bicycle ergometer for predicting maximal METs in a female population between the ages of 19 and 29 years.

Subjects

The subjects were 25 female volunteers, between the ages of 19 and 29 years, from the University of Wisconsin-La Crosse and the La Crosse, Wisconsin community. The sample of females were of a nonsedentary nature, willing, and able to perform the tests. The activities in which they participated were walking, jogging, swimming, bicycling, weight lifting, aerobic dance, and participation in sports. Only 21 subjects were included in statistical analyses. Four subjects were not included because they did not meet the criteria for a maximal test. Descriptive characteristics for the 21 subjects are presented in Table 2.

Instrumentation

Heart rate measurements during the submaximal and maximal exercise tests were measured using the UNIQ CIC Heart Watch Model 8799 (Polar Electro Oy, 1989). Oxygen consumption measurements in l/min were determined from expired gas volumes during maximal exercise tests. The gas analysis measurements were made by open circuit spirometry using the

Table 2. Descriptive characteristics of subjects (N = 21)

Variable	Mean	Standard Deviation	Range
Age (years)	24.57	± 2.75	19-29
Height (cm)	163.79	± 5.71	152-172.5
Weight (kg)	61.04	± 8.45	44.1-80.2

Quinton Q-Plex Model Q-Plex I (Quinton Instrument Corporation, 1989). Prior to calibrating the Q-Plex, oxygen and carbon dioxide concentrations of the calibration gases were previously measured by the Scholander technique. The Q-Plex was then calibrated using those values before testing each subject for the maximal bicycle test. Room temperature, barometric pressure, and humidity were recorded before each test. The submaximal and maximal tests were performed on the Schwinn Air-Dyne bicycle ergometer.

Fitness Level Determination

Pretesting Procedure

Submaximal and maximal bicycle ergometer tests took place in the Human Performance Laboratory located in Mitchell Hall at the University of Wisconsin-La Crosse. Subjects reported to the Human Performance Laboratory having abstained from food, alcohol, and caffeine for at least 3 hours. Informed consent and medical history/physical activity forms were administered and completed (see Appendices A and B). The subject's weight was measured without shoes to the nearest 0.5 lb. Pounds were divided by 2.2 lbs/kg for conversion to the nearest 0.1 kg. The heart rate transmitter was strapped around the subject's chest and the watch placed to the side of the bicycle for easy viewing by the researcher. The subject sat in a chair for 2 minutes beside the bicycle to obtain a resting heart rate. Arm and leg stretches were performed to reduce the risk of injury. The subject was then allowed to adjust the seat to a comfortable height and become familiar with the Schwinn Air-Dyne bicycle ergometer. At this point, the researcher explained how the display module would show the workload level number. The workload levels changed with an increase or decrease in pedal frequency.

Testing Procedure

The fitness test instructions (Nagle, 1988b; Schwinn Bicycle Company, 1988) for the Schwinn Air-Dyne have a Part A and Part B. In Part A, a predicted maximal heart rate (max. heart rate) was calculated from the equation 220 - age. Two workloads were chosen for the submaximal exercise test according to the person's weight (see Table 3). In this study, the weight-interval category was assigned specific kilogram values. When the subject's heart rate was within 10 beats of resting, she began to exercise on the Air-Dyne continuously for 8 minutes: 4 minutes at the first workload and 4 minutes at the second workload. At 3:45 minutes, the first heart rate (heart rate 1) was recorded (see Appendix C). At 7:45 minutes, the second heart rate (heart rate 2) was recorded. The subject then performed a cool-down pedaling the ergometer at a comfortable workload level less than 1.0, which is equivalent to 300 kpm/min of resistance, for 2 minutes. If the first heart rate (heart rate 1) did not exceed 120 bpm, the test was stopped and Part B was executed after the subject's heart rate was within 10 beats of her resting heart rate.

Table 3. Air-Dyne load settings in kilograms for aerobic fitness assessments

Weight Category (Kg.)	Part A Workload Level 1st	Part A Workload Level 2nd	Part B Workload Level 1st	Part B Workload Level 2nd
44.1-46	0.5	1.3	1.0	1.9
46.1-48	0.5	1.4	1.1	2.0
48.1-50	0.6	1.4	1.1	2.1
50.1-52	0.6	1.5	1.1	2.2
52.1-54	0.6	1.5	1.2	2.3
54.1-56	0.7	1.6	1.2	2.4
56.1-58	0.7	1.7	1.3	2.5
58.1-60	0.7	1.7	1.3	2.6
60.1-62	0.7	1.8	1.4	2.7
62.1-64	0.8	1.8	1.4	2.7
64.1-66	0.8	1.9	1.4	2.8
66.1-68	0.8	1.9	1.5	2.9
68.1-70	0.8	2.0	1.5	3.0
70.1-72	0.8	2.1	1.6	3.1
72.1-74	0.9	2.2	1.6	3.2
74.1-76	0.9	2.2	1.7	3.3
76.1-78	0.9	2.3	1.7	3.3
78.1-80	0.9	2.3	1.8	3.4
80.1-82	1.0	2.4	1.8	3.5
82.1-84	1.0	2.5	1.8	3.6
84.1-86	1.0	2.5	1.9	3.7
86.1-88	1.0	2.6	1.9	3.8
88.1-90	1.1	2.6	2.0	3.8
90.1-92	1.1	2.7	2.0	3.9
92.1-94	1.1	2.7	2.1	4.0
94.1-96	1.1	2.8	2.1	4.1
96.1-98	1.2	2.8	2.2	4.2
98.1-100	1.2	2.9	2.2	4.3
100.1-102	1.2	2.9	2.2	4.3
102.1-104	1.2	3.0	2.3	4.4
104.1-106	1.3	3.0	2.3	4.5
106.1-108	1.3	3.1	2.4	4.6
108.1-110	1.3	3.1	2.4	4.7

In Part B, predicted maximal heart rate (max heart rate) was calculated as 205 - (1/2 * age). Workloads were determined for the subject's weight (see Table 3). The subject began to exercise when her heart rate was within 10 beats of resting and exercised continuously for

8 minutes: 4 minutes at the first workload and 4 minutes at the second workload. At 3:45 minutes the first heart rate (heart rate 1) was recorded and at 7:45 minutes the second heart rate (heart rate 2) was recorded (see Appendix C). The subject performed a cool-down at a comfortable workload level less than 1.0 for 2 minutes.

Posttesting Procedure

Predicted maximal METs for Part A was calculated using the following formula:

$$\text{Predicted Maximal METs} = \frac{3(\text{max. heart rate}) + 3(\text{heart rate 2}) - 6(\text{heart rate 1})}{(\text{heart rate 2}) - (\text{heart rate 1})}$$

Predicted

Predicted maximal METs for Part B was calculated using the following formula:

$$\text{Predicted Maximal METs} = \frac{3.6(\text{max. heart rate}) + 4.8(\text{heart rate 2}) - 8.4(\text{heart rate 1})}{(\text{heart rate 2}) - (\text{heart rate 1})}$$

The predicted maximal METs obtained from the calculation would determine a fitness level category from the aerobic fitness ratings (Nagle, 1988b).

Aerobic Fitness Ratings

poor	< 8.0	METs
fair	8.1-10.0	METs
good	10.1-10.9	METs
excellent	> 11.0	METs

Maximal Test Practice

During the submaximal test session, a practice session for the maximal Air-Dyne bicycle test was held after the submaximal test. Subjects not familiar with a maximal test were equipped with headgear, noseclip, and mouthpiece to become comfortable with the feel of the insertion of the mouthpiece. The practice session followed the workload increments of the maximal test (see Table 4), however, subjects were permitted and encouraged to make a smooth transition from one workload level to the next. The practice session time involvement varied for each subject according to the subject's ability to be comfortable with the maximal test.

Maximal MET Determination

Pretesting Procedure

Subjects returned to the Human Performance Laboratory 2 to 6 days after the submaximal test at approximately the same time of day to perform the maximal MET test on the Schwinn Air-Dyne bicycle ergometer. Each subject was measured without shoes to the nearest 0.5 cm and weighed to the nearest 0.1 kg. The heart rate transmitter was strapped around the subject's chest and the heart rate watch placed to the side of the bicycle. Arm and leg stretches were performed to minimize any risk of injury. Each subject was fitted with the necessary equipment needed to be connected to the Q-Plex for gas analysis in terms of $\dot{V}O_2$ in l/min (STPD) and RER. Equipment included head gear, nose clip, mouthpiece, and hose. Each subject performed a warm-up exercise at workload 1.0 for 3 minutes. The Borg Rating of Perceived Exertion Scale (Borg, 1973) was verbally explained to each subject. Rating of Perceived Exertion (RPE) was used by the researcher to monitor the subject's progress during the test. Heart rate and RPE were recorded every minute of the test (see Appendix D). Heart rate was recorded at maximal exercise. The Q-Plex was programmed for gas analysis every 20 seconds of exercise.

Table 4. Protocol for maximal air-dyne test

Workload	Kpm/min	Time(min)
2.0	600	2
2.5	750	2
3.0	900	2
3.5	1050	2
4.0	1200	2
4.5	1350	2
5.0	1500	2
5.5	1650	2
6.0	1800	2

Testing Procedure

The subject began at workload 2.0, which is equivalent to 600 kpm/min, for 2 minutes and the workload was increased by 150 kpm/min every two minutes until volitional exhaustion (See Table 4). The changes in workload were accomplished by increasing pedal frequency and seen on the display module. Verbal encouragement was given by the researcher for the subject to reach a maximal effort. The test was stopped at this point. The subject then performed a cool-down at a comfortable workload less than 2.0 for 3 to 5 minutes.

Posttesting Procedure

A "true" maximal VO_2 was obtained if the subject reached a respiratory exchange ratio (RER) > 1.00 (McArdle, Katch, & Katch, 1986) or a maximal heart rate no more than 10 beats below the age predicted heart rate of 220 - age (Kline et al., 1987). Maximal oxygen consumption (VO_2 max) expressed as l/min was converted by the recorded subject's weight to ml/kg/min by the following equation:

$$\frac{VO_2 \text{ max l/min}}{\text{weight (kg)}} = VO_2 \text{ max ml/kg/min}$$

Maximal METs attained were computed from the following equation:

$$\frac{VO_2 \text{ max ml/kg/min}}{3.5 \text{ ml/kg/min}} = \text{maximal METs}$$

Statistical Analyses

Descriptive statistics were used to define the study population. Pearson product-moment correlations and paired t-tests were used to compare the predicted maximal METs to the measured maximal METs. Significance was set at $p < .05$.

CHAPTER IV

RESULTS AND DISCUSSION

Maximal Test Results

One submaximal bicycle test and one maximal bicycle test were performed by each subject on the Schwinn Air-Dyne bicycle ergometer. The average temperature and relative humidity on test days was 23.3 degrees Celsius and 61%, respectively. The maximal test took place 2 to 6 days after the submaximal test. Heart rates were measured by the UNIQ CIC Heart Watch during both tests and physiological responses were measured using the Quinton Q-Plex Metabolic Cart during the maximal test. Results from the maximal test are presented in Table 5.

Table 5. Physiological responses during the maximal test

Variable	Mean	Standard Deviation	Range
RER max	1.02	± 0.05	0.93-1.14
HR max	187	± 7.85	168-197
$\dot{V}O_2$ max (l/min)	2.57	± 0.46	1.95-3.64
$\dot{V}O_2$ max (ml/kg/min)	42.62	± 8.3	27.8-60.5
METs	12.18	± 2.36	7.94-17.29

Twenty-one subjects had valid $\dot{V}O_2$ max tests, based on attaining at least one out of two criteria needed for a valid maximal test. The criteria included an RER > 1.00 and a maximal heart rate within at least 10 beats of age predicted maximal heart rate (220 - age). The average time spent to complete the maximal test was 9.6 minutes with a range of 6 to 17 minutes for the 21 subjects.

Raw data from the maximal test can be found in Appendix E. Maximal RER ranged from 0.93 to 1.14. Eight subjects who did reach the criterion of 10 beats within age predicted maximal heart rate, did not reach an RER > 1.00. Maximal heart rate values ranged from 168 to 197 bpm. Five subjects who did reach an RER > 1.00, did not attain a maximal heart rate within 10 beats of age predicted maximal heart rate. However, 12 subjects did attain an RER > 1.00 and a maximal heart rate within 10 beats of age predicted maximal heart rate.

The $\dot{V}O_2$ max (ml/kg/min) values of the subjects in the study indicate a wide range (27.8 to 60.5) of cardiorespiratory fitness levels ranging from fair to high as compared to available norms (American Heart Association, 1972). Table 6 presents the cardiorespiratory fitness classifications for females. The $\dot{V}O_2$ max values (l/min) of the 21 subjects in the present study converted to maximal METs ranging from 7.94 to 17.29.

<u>Validation of Predicted Maximal METs Using the Schwinn Air-Dyne</u>

This section details the results and analyses of the accuracy of the prediction equations. Each subject participated in an 8 minute submaximal bicycle test which predicted maximal METs using age predicted maximal heart rate and two submaximal heart rates. The equations were developed by Nagle (1988a).

Each subject pedaled at two workloads determined by her weight for

Table 6. Cardiorespiratory fitness classifications of females (expressed in ml/kg/min)

Age	Low	Fair	Average	Good	High
20-29	<24	24-30	31-37	38-48	>49
30-39	<20	20-27	28-33	34-44	>45
40-49	<17	17-23	24-30	31-41	>42
50-59	<15	15-20	21-27	28-37	>38
60-69	<13	13-17	18-23	24-34	>35

Note: American Heart Association, 1972. Exercise testing with apparently healthy individuals: A handbook for physicians, p. 15.

4 minutes each. Submaximal heart rates 1 and 2 were recorded before the fourth and eighth minutes, respectively, for two workloads (see Appendix F). In the event the first heart rate was recorded 120 bpm or greater, the following prediction equation was used:

$$\text{Predicted Maximal METs} = \frac{3(\text{max. heart rate}) + 3(\text{heart rate 2}) - 6(\text{heart rate 1})}{(\text{heart rate 2}) - (\text{heart rate 1})}$$

The predicted maximal heart rate was calculated 220 - age. Only one subject experienced a heart rate greater than 120 bpm at the first workload. In the event the first recorded heart rate was lower than 120 bpm, the following prediction equation was used:

$$\text{Predicted Maximal METs} = \frac{3.6(\text{max. heart rate}) + 4.8(\text{heart rate 2}) - 8.4(\text{heart rate 1})}{(\text{heart rate 2}) - (\text{heart rate 1})}$$

The predicted maximal heart rate was calculated 205 - (1/2 * age).

The results of the predicted maximal MET equations were compared to the actual maximal METs measured during the maximal test on the Schwinn Air-Dyne. The means of the prediction equation and measured maximal

METs are presented in Table 7. The mean of measured maximal METs on the Schwinn Air-Dyne for the 21 subjects was 12.18 ± 2.36 METs. The mean of predicted maximal METs calculated from the heart rate response was 11.62 ± 2.46 METs.

A paired t-test and Pearson product-moment correlation were performed to compare the prediction equation values to measured maximal values. There was a significant difference ($p < 0.05$) between the predicted maximal METs and the measured maximal METs in this group of females. Even with the significant difference in scores of the group, the correlation was still high at $r = .88$. Overall, the prediction of maximal METs underestimated the measured maximal METs. The underestimation of maximal METs was seen in all subjects except six (see Figure 1).

Table 7. Comparison of maximal values and prediction equation values

	Measured Maximal METs	Predicted Maximal METs	r	t	p
Mean ± SD	12.18 ± 2.36	11.62 ± 2.46	.88	2.18	.04
Range	7.94-17.29	7.75-17.47			

The mean derived from the maximal MET prediction equation was approximately 0.56 METs lower than the mean from measured maximal METs obtained on the Schwinn Air-Dyne bicycle ergometer. This is a 4.6% difference.

Discussion

Nagle's (1988a) study from the Excelsior Fitness Report on Airdyne

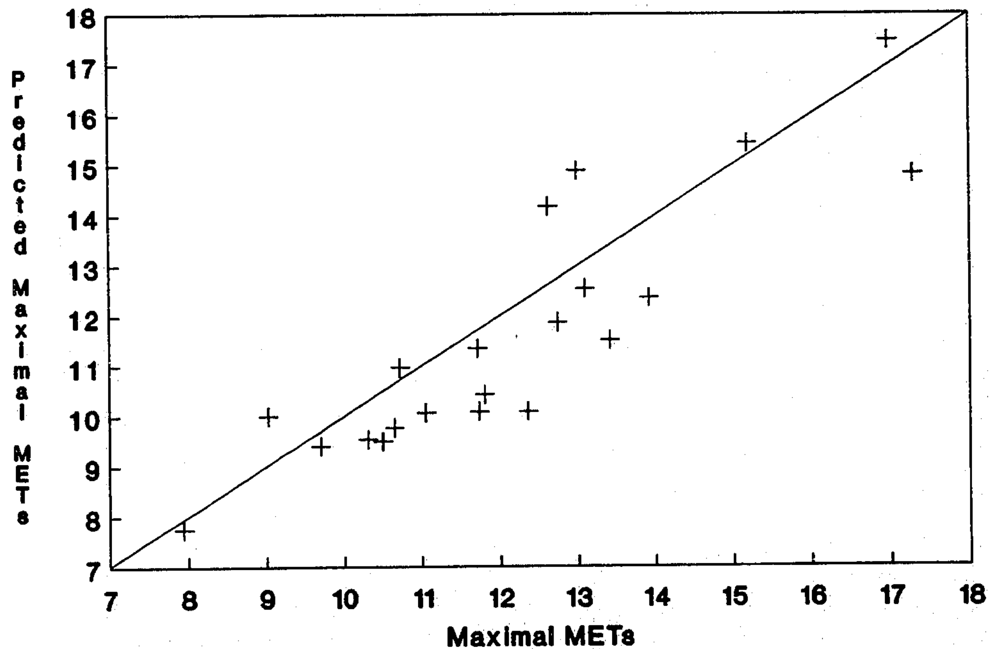

Figure 1. Predicted Versus Maximal METs

used 51 subjects, but 42 were firefighters. The 51 subjects had a measured mean $\dot{V}O_2$ max of 46.5 ± 8.1 ml/kg/min, which would be approximately equivalent to 13.3 METs. The present study was believed by the researcher to have a more appropriate study sample for validating a fitness level equation which is available to the public in an owner's manual. Nagle's (1988a) study sample only included 9 females, whereas the present study used 21 females to determine the validity of the prediction equations. The study sample was a homogeneous population group from a variety of fitness level classifications.

Nagle's study (1988a) of the comparison of the measured means of $\dot{V}O_2$ max to the prediction of $\dot{V}O_2$ max (ml/kg/min) using the measured maximal heart rate resulted in a 12% difference. The comparison of measured $\dot{V}O_2$ max to the prediction of $\dot{V}O_2$ max using a predicted maximal heart rate calculated as 220 - age resulted in a 13% difference. Predicting $\dot{V}O_2$ max using the predicted maximal heart rate of 205 - (1/2 * age), resulted in an 11% difference. The present study resulted in a 4.6% difference between measured maximal METs and predicted maximal METs with the maximal MET prediction equation underestimating maximal METs. In the comparison of predicted and measured maximal METs, only two subjects' results had a greater than 2 MET underestimation. Thirteen subjects' maximal MET values were within ±1 MET (see Appendix G).

Similar results of $\dot{V}O_2$ max underestimation have been reported by other researchers. The predictability of $\dot{V}O_2$ max (l/min) from submaximal cycle ergomtry and bench stepping tests underestimated measured $\dot{V}O_2$ max values by 0.13 to 0.55 l/min in four submaximal test protocols, two progressive and two steady state protocols (Fitchett, 1985). From a submaximal cycle ergometry test, Wilmore et al. (1986) found 10 of 12 $\dot{V}O_2$ max prediction equations to underestimate the mean predicted value from the true value. The best multiple regression equation resulted in a mean difference of 9.9% between the predicted and true values. McArdle, Katch, and Katch (1986) utilized a step height of 16 1/4 inches (41.275 cm) for a 3-minute step test. The prediction of $\dot{V}O_2$ max equations for men and women predicted $\dot{V}O_2$ max within $\pm$16% of a true $\dot{V}O_2$ max. Francis and Cuipepper (1988) validated a 3 minute height-adjusted step test. The average step height observed was 32.5 cm. Their results showed a prediction of $\pm$7% within actual values of a treadmill test and step test.

There is the possibility in the present study that the subjects did not reach their actual $\dot{V}O_2$ max. Only one criterion of two was set to meet the requirements of a "true" $\dot{V}O_2$ max. During the study, this researcher concluded that a maximal test was difficult to complete on the Schwinn Air-Dyne bicycle ergometer. The Air-Dyne workloads increase by pedal frequency and not by an increase in resistance as do other cycle ergometers. As was the case in this study, all subjects continued until complete exhaustion. However, local fatigue may have been the cause for terminating the maximal test rather than the taxing of the cardiorespiratory system. This may be the reason for the low RER values (see Appendix E). The results of the study may have changed if the $\dot{V}O_2$ max was determined by another mode of exercise. The results showed a 4.6% difference between predicted and measured maximal METs on the Schwinn Air-Dyne. Possibly if $\dot{V}O_2$ max had been determined on the treadmill or another bicycle ergometer under stricter criteria of a "true" $\dot{V}O_2$ max, the percentage difference would be more consistent with the 11% difference obtained by Nagle (1988a).

Nagle's (1988a) study and the present study were within the limits of a study by Astrand and Ryhming (1954). Their nomogram which calculated aerobic capacity from heart rates obtained at submaximal workloads was 85% accurate. Stated another way, the nomogram predicts within an error of $\pm$15%. Nagle (1988a) showed an 11% difference between measured $\dot{V}O_2$ max and predicted $\dot{V}O_2$ max utilizing a predicted maximal heart rate calculated as 205 - (1/2 * age) The present study showed a 4.6% difference between measured maximal METs and predicted maximal METs. The predicted maximal MET equations should not be used for research purposes.

CHAPTER V

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

Summary

The purpose of this study was to determine if the maximal MET prediction equations using the Schwinn Air-Dyne bicycle ergometer were an accurate method for predicting maximal METs in females, 19 to 29 years of age.

Twenty-five females between the ages of 19 and 29 years participated in the validation study. Each subject performed an 8 minute submaximal exercise test and an actual $\dot{V}O_2$ max test on the Schwinn Air-Dyne. The variables in the prediction equation included age predicted maximal heart rate and two submaximal heart rates. The physiological parameters measured during the actual $\dot{V}O_2$ max test included oxygen consumption (l/min), respiratory exchange ratio (RER), and maximal heart rate (bpm).

The statistical analyses included means, standard deviations, and ranges for the descriptive characteristics of 21 subjects who completed the $\dot{V}O_2$ max test under established criteria of a maximal exercise test. Comparisons between measured and predicted maximal METs were made using a paired t-test and a Pearson product-moment correlation. Significance was set at $p < .05$.

Conclusions

Based on the results of this study, the following conclusions were reached:

1. There was a high positive correlation (r - .88) between the predicted maximal METs and the measured maximal METs in this group of female subjects. This supports the first hypothesis which states there would be a high positive correlation (r = .80) between predicted maximal METs and measured maximal METs. Therefore, the first hypothesis was accepted.

2. It was found that the predicted maximal MET values were significantly different from the measured maximal MET values. This disagreed with the null hypothesis which stated there would not be a significant difference between the means of predicted maximal METs and measured maximal METs. Therefore, the second hypothesis was rejected. The results of this study showed there was an approximate 0.56 MET underestimation of maximal METs. This underestimation explains the significant difference of 4.6% between the means of predicted and measured maximal METs.

Maximal MET prediction equations which predict accurately with no significant difference between means would be best. Usage of prediction equations depends on the accuracy needed for that particular situation. The present study showed that the maximal MET prediction equations would be valid for determining maximal METs for females age 19 to 29 years within an accuracy of less than 5%. In conclusion, the maximal MET prediction equations predicted quite accurately with a minimal amount of difference between means of predicted and measured maximal METs and therefore could be used for determining maximal METs in fitness and health clubs.

Recommendations

The following recommendations are offered for consideration:

1. The maximal MET prediction equations for the Schwinn Air-Dyne bicycle ergometer should be validated with males and females of other age groups.

2. The maximal MET prediction equations should be validated with distinct and varied fitness level groups.

3. Predicted maximal MET values abtained on the Schwinn Air-Dyne should be compared to the VO_2 max values determined with another bicycle ergometer test or a maximal treadmill test.

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APPENDIX A

INFORMED CONSENT

PREDICTED MAXIMAL MET VALIDATION STUDY

INFORMED CONSENT

I, ______________________, have volunteered to be in this study to determine if the Schwinn Air-Dyne fitness level equation can be considered a valid equation for the prediction of maximal aerobic fitness. I understand this study consists of one submaximal bicycle test and one maximal bicycle test using the Schwinn Air-Dyne.

The submaximal bicycle test will consist of pedaling for eight continuous minutes at workloads selected according to my weight. My heart rate will be monitored by the UNIQ CIC Heart Watch. An electrode strap and transmitter will be around my chest. The maximal bicycle test will consist of pedaling at a minimal resistance with increasing amounts of work until I reach a maximal effort. My heart rate will be monitored by the UNIQ CIC Heart Watch and recorded every minute of exercise. My perceived exertion during the exercise test, as will be explained by the investigator, will also be recorded every minute. I will have on a nose clip and head gear. I will breathe in room air through a mouthpiece and be connected by tubing to a metabolic cart where my exhaled air will be collected and analyzed. Although this test requires a maximal effort, I understand I may withdraw from the test at any time.

Arm and leg stretches will be performed to minimize any risk of injury. Practice session on the Schwinn Air-Dyne and adjustment of the bicycle seat to a comfortable position will be allowed before the tests. The display module and rating of perceived exertion scale will be explained at that time.

There exists the possibility of unforeseen changes occurring during or after the tests. They may include symptoms of leg fatigue, arm soreness, shortness of breath, fainting, and in rare instances heart attack or death. The researcher is adequately trained in emergency procedures. If any abnormal symptoms occur, the tests will be terminated.

The information and data obtained for this study will be treated as privileged and confidential. The data however will be used for statistical analysis. To the best of my knowledge I do not have any physical limitations that would prevent me from participating in this study. I have read the above policies and procedures. I understand the possible risks involved and what is expected of me for this study. All questions that have occurred to me have been answered to my satisfaction. I voluntarily consent to be a subject in this study and understand I may end my participation at any time without penalty.

Signature ______________________ Date __________

Witness ______________________ Date __________

APPENDIX B

MEDICAL HISTORY AND PHYSICAL ACTIVITY FORM

PREDICTED MAXIMAL MET VALIDATION STUDY

MEDICAL HISTORY AND PHYSICAL ACTIVITY FORM

NAME ______________________ DATE __________
ADDRESS ______________________ CITY/STATE __________
PHONE __________ AGE ____ BIRTH DATE ___/___/___

Medical History

Check if you have had any of the following:

PAST HISTORY	DATE
___ Heart Disease	____
___ Rheumatic Fever	____
___ Chest Pain/Angina	____
___ Mitral Valve or other Heart Murmur	____
___ Diabetes Mellitus	____
___ High Blood Pressure	____
___ COPD/Emphysema	____
___ Asthma	____
___ Seizures	____
___ Back, Knee or Ankle Injuries	____
___ Other Injury	____
______________________	

PRESENT SYMPTOMS

Have you recently had:

Chest Pain	___ yes	___ no
Shortness of Breath	___ yes	___ no
Heart Palpitations	___ yes	___ no
Cough on Exertion	___ yes	___ no
Coughing up Blood	___ yes	___ no
Back Pain	___ yes	___ no
Swollen, Stiff or Painful Joints	___ yes	___ no
Other	___ yes	___ no
______________________		

Current Medications

Name	Dosage	How Often

Physical Activity continued on next page

Physical Activity

1. Do you exercise on a regular basis? ___ yes ___ no

2. Check the activities below in the left column that you perform.

3. For each activity, place the number in the right columns from the choices below that best describes how often and how long you exercise.

choices: how often		choices: how long
< once/week		< 20 min/session
1x/week	2x/week	20 min/session
3x/week	4x/week	30 min/session
5x/week	6x/week	40 min/session
> 6x/week		> 40 min/session

		how often/week	time/session
___	walking	___	___
___	jogging/running	___	___
___	swimming	___	___
___	bicycling	___	___
___	weight lifting	___	___
___	rowing	___	___
___	bowling	___	___
___	golfing	___	___
___	tennis/racquetball	___	___
___	aerobic dance	___	___
___	basketball/softball	___	___
___	other		
	___	___	___
	___	___	___

4. How would you rate your level of fitness?

   ___ poor
   ___ fair
   ___ good
   ___ excellent

I hereby certify the above medical history information and physical activity statements provided by me are complete and true to the best of my knowledge. I am free of heart disease or injuries which would prevent me from performing a maximal effort bicycle test.

Signature ______________________ Date ____________

Witness ______________________ Date ____________

APPENDIX C

DATA SHEET

SUBMAXIMAL AIR-DYNE TEST

PREDICTED MAXIMAL MET VALIDATION STUDY

DATA SHEET

SUBMAXIMAL AIR-DYNE TEST

NAME ______________________________ DATE ______________

BIRTHDATE __________ AGE _____ WEIGHT _____LBS/2.2 = ______KG

WEIGHT CATEGORY _______KG

RESTING HEART RATE _______BPM

PART A

MAXIMAL HEART RATE (220 - age) ________BPM

WORKLOAD #1 _______ HEART RATE _______BPM (MINUTE 3:45)

WORKLOAD #2 _______ HEART RATE _______BPM (MINUTE 7:45)

$$\text{PREDICTED MAXIMAL METS} = \frac{3(\text{MAX. HR}) + 3(\text{HR-2}) - 6(\text{HR-1})}{(\text{HR-2}) - (\text{HR-1})} = \_\_\_\_\_\_\_\text{METS}$$

PART B

MAXIMAL HEART RATE (205 - 1/2 * AGE) = _______BPM

WORKLOAD #1 _______ HEART RATE _______BPM (MINUTE 3:45)

WORKLOAD #2 _______ HEART RATE _______BPM (MINUTE 7:45)

$$\text{PREDICTED MAXIMAL METS} = \frac{3.6(\text{MAX. HR}) + 4.8(\text{HR-2}) - 8.4(\text{HR-1})}{(\text{HR-2}) - (\text{HR-1})} = \_\_\_\_\_\_\_\text{METS}$$

AEROBIC FITNESS RATINGS		
POOR	< 8.0	METs
FAIR	8.1-10.0	METs
GOOD	10.1-10.9	METs
EXCELLENT	> 11.0	METs

FITNESS LEVEL

____

APPENDIX D

DATA SHEET

MAXIMAL AIR-DYNE TEST

PREDICTED MAXIMAL MET VALIDATION STUDY

DATA SHEET

MAXIMAL AIR-DYNE TEST

NAME ______________________ DATE ______________

BIRTHDATE __________ AGE _____ HEIGHT _______CM WEIGHT _______KG

AGE PREDICTED MAXIMAL HEART RATE (220 - age) _______BPM

PROTOCOL

WORKLOAD LEVEL	KPM/MIN	TOTAL TIME(MIN)	HR	RPE
2.0	600	1	____	____
		2	____	____
2.5	750	3	____	____
		4	____	____
3.0	900	5	____	____
		6	____	____
3.5	1050	7	____	____
		8	____	____
4.0	1200	9	____	____
		10	____	____
4.5	1350	11	____	____
		12	____	____
5.0	1500	13	____	____
		14	____	____
5.5	1650	15	____	____
		16	____	____
6.0	1800	17	____	____
		18	____	____

TIME COMPLETED _________MIN
MAXIMAL HR ATTAINED _______BPM MAXVO2 = __________L/MIN
R VALUE ATTAINED ______

$\frac{\text{MAXVO2 L/MIN}}{\text{KG}}$ = _________ML/KG/MIN

$\frac{\text{MAXVO2 ML/KG/MIN}}{\text{3.5 ML/KG/MIN}}$ = _________MAXIMAL METS

APPENDIX E

RAW DATA FROM THE MAXIMAL SCHWINN AIR-DYNE TEST

Raw Data from the Maximal Schwinn Air-Dyne Test

Ss	Age (yrs)	Wt (kg)	RER	HR	VO2 (l/min)	METs
1	23	79.3	1.00	187	2.203	7.94
2	20	60.9	1.02	192	2.067	9.70
3	24	60.0	1.07	188	2.205	10.50
4	29	54.1	1.06	188	1.953	10.31
5	27	71.8	1.02	190	2.677	10.65
6	29	61.6	1.14	168	1.946	9.03
7	23	63.4	0.95	192	2.451	11.05
8	23	71.8	1.01	194	2.949	11.73
9	24	72.7	0.98	197	3.144	12.36
10	26	60.7	1.07	188	2.507	11.80
11	26	60.0	1.01	178	2.251	10.72
12	23	58.4	0.98	188	2.394	11.71
13	27	62.3	0.95	194	2.924	13.41
*14	22	71.8	0.93	185	3.188	12.69
15	21	43.9	1.04	184	1.957	12.74
16	24	62.3	0.96	187	3.036	13.92
17	27	56.1	0.95	185	2.570	13.09
18	19	64.5	1.03	173	2.849	12.62
19	25	60.2	0.93	197	3.642	17.29
20	23	49.1	1.10	174	2.233	12.99
21	25	54.5	1.02	192	2.897	15.19
*22	24	76.1	0.93	183	4.512	16.94
23	28	50.5	1.04	192	3.002	16.98
*24	27	59.5	0.95	171	3.091	14.84
*25	27	65.2	0.99	178	3.622	15.87

* indicates subjects not used in the final analyses

APPENDIX F

RAW DATA FROM THE PREDICTED MAXIMAL MET SCHWINN AIR-DYNE TEST

Raw Data from the Predicted Maximal MET Schwinn Air-Dyne Test

Subjects	Age (yrs)	Weight (kg)	Workload 1	Workload 2	Heart Rate 1	Heart Rate 2	METs
1	23	80.2	1.0	2.4	121	169	7.75
2	20	60.9	1.4	2.7	140	183	9.41
3	24	60.0	1.3	2.6	129	178	9.50
4	29	54.1	1.2	2.4	130	176	9.54
5	27	71.4	1.6	3.1	110	169	9.77
6	29	62.3	1.4	2.7	121	169	10.01
7	23	63.6	1.4	2.7	132	174	10.07
8	23	71.4	1.6	3.1	120	170	10.09
9	24	73.9	1.6	3.2	118	169	10.09
10	26	60.2	1.4	2.7	117	165	10.43
11	26	59.8	1.3	2.6	132	167	10.97
12	23	58.4	1.3	2.6	108	155	11.35
13	27	62.3	1.4	2.7	89	144	11.51
*14	22	71.4	1.6	3.1	115	156	11.74
15	21	44.1	1.0	1.9	116	156	11.87
16	24	62.7	1.4	2.7	109	149	12.36
17	27	56.4	1.3	2.5	99	142	12.54
18	19	64.3	1.4	2.8	96	134	14.18
19	25	60.9	1.4	2.7	98	132	14.81
20	23	48.6	1.1	2.1	87	125	14.89
21	25	55.9	1.2	2.4	101	132	15.43
*22	24	73.4	1.6	3.2	103	130	16.80
23	28	50.5	1.1	2.2	100	126	17.47
*24	27	60.9	1.4	2.7	96	123	17.53
*25	27	66.1	1.5	2.9	90	115	19.42

* indicates subjects not used in final analyses

APPENDIX G

COMPARISON OF PREDICTED AND MEASURED MAXIMAL METS

Comparison of Predicted and Measured Maximal METs

Subjects	Age (yrs)	Maximal METs	Predicted Maximal METs	Difference
1	23	7.94	7.75	-0.19
2	20	9.70	9.41	-0.29
3	24	10.50	9.50	-1.00
4	29	10.31	9.54	-0.77
5	27	10.65	9.77	-0.88
6	29	9.03	10.01	+0.98
7	23	11.05	10.07	-0.98
8	23	11.73	10.09	-1.64
9	24	12.36	10.09	-2.27
10	26	11.80	10.43	-1.37
11	26	10.72	10.97	+0.25
12	23	11.71	11.35	-0.36
13	27	13.41	11.51	-1.90
*14	22	12.69	11.74	-0.95
15	21	12.74	11.87	-0.87
16	24	13.92	12.36	-1.56
17	27	13.09	12.54	-0.55
18	19	12.62	14.18	+1.56
19	25	17.29	14.81	-2.48
20	23	12.99	14.89	+1.90
21	25	15.19	15.43	+0.24
*22	24	16.94	16.80	-0.14
23	28	16.98	17.47	+0.49
*24	27	14.84	17.53	+2.69
*25	27	15.87	19.42	+3.55

* indicates subjects not used in the final analyses