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The Utilization of Self-Report Questionnaires to Predict Ventilatory Threshold

By

Erin K. Riley

B.S. University of Kansas

Lawrence, Kansas 1999

Presented in partial fulfillment of the requirements

for the degree of

Master of Science

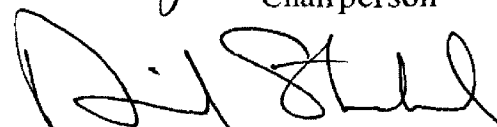
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Missoula, MT

2002

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The Utilization of Self-Report Questionnaires to Predict Ventilatory Threshold

Director: Steven E. Gaskill, Ph.D.



ABSTRACT: PURPOSE: The purpose of this project was to predict VO_2 at the ventilatory threshold ($\text{VO}_{2\text{vt}}$) based on sustainable fitness data collected from self-report questionnaires. Equations to predict $\text{VO}_{2\text{vt}}$ were developed based on descriptive data and reported intensity of sustained exercise. **METHODS:** Male and female subjects ($N=63$) each completed a Sustainable Fitness Questionnaire, compiled at the University of Montana, to estimate average exercise expenditures. A graded treadmill test with collection of metabolic gases was used to determine ventilatory threshold. During the treadmill tests subjects walked at a constant self-selected speed and the treadmill grade was increased one percent each minute. HR and RPE were collected each minute. Following testing, the questionnaires were coded using the Compendium of Physical Activities and maximal sustained VO_2 during exercise ($\text{VO}_{2\text{sustained}}$) was estimated based on these results. Stepwise multiple regression models were used to develop prediction equations for $\text{VO}_{2\text{vt}}$. Cross validation was completed using the Press cross validation method. **RESULTS:** Sixty-three subjects with adequate determination of VT were analyzed. When the group was analyzed as a whole, gender and $\text{VO}_{2\text{sustained}}$ were significant at the $p < 0.01$ level when added to the stepwise regression model ($R^2=0.4934$). When multiple regression analysis was completed by gender the results were improved for the males ($R^2=0.6260$), but was not improved for the females ($R^2=0.4950$). Separation by fitness level improved the predictive ability of the models. For the lower fit group, both BMI and gender were added to the model ($R^2=0.6742$), for the higher fit group, BMI and maximal sustained VO_2 of reported activity levels were added to the model ($R^2=0.7338$). **CONCLUSIONS:** These data show that gender and $\text{VO}_{2\text{sustained}}$ are significant predictors of $\text{VO}_{2\text{vt}}$ when analyzing diverse populations. When multiple regression analyses were completed by gender, the results were improved for the males but not the females. Separation by fitness levels also improved the predictive ability of the models. Self reported intensity of activity improves the prediction of $\text{VO}_{2\text{vt}}$, especially in more fit individuals.

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This thesis would not have been complete without the help of a few key people. A huge thank you to Dr. Gaskill who's never ending patience, knowledge, and assistance will always be appreciated. Dr. Ruby and Dr. Laskin also deserve a thank you for serving on my committee. Thanks to Dusty for all of his wisdom and leadership. The other frustrated grad students, Lori and Andy, have made this an experience not to be forgotten. I couldn't have survived this project without the moral and financial support of Mom and Dad, the absolute best parents in the world. Without them, I might not have ever taken on this adventure. Mikael, who has been the most amazing person in my life, deserves the biggest round of applause for his confidence in me as well as his incredible patience.

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Chapter One

INTRODUCTION

Introduction

Perceived exertion is the single best indicator of the degree of physical strain (Borg, 1982). Subjects' perceived exertion during exercise is typically closely matched with exercise intensities measured by gas exchange methods. Although VO_2max has been used extensively in research and exercise prescription, ventilatory threshold (VT) is rapidly becoming a more widely accepted method to evaluate cardiovascular fitness.

The maximal intensity aerobic exercise that can be sustained for an extended duration of several hours is just below an individual's VT (McArdle, 1996). VT also appears to be an excellent marker of the intensity of training that is sustained during an aerobic training program (Slivka, 2001). In addition, several recent studies have focused on the use of VT as an indicator of sustainable aerobic fitness (Reybrouck, 1983, Cunningham, 1985, Londeree, 1997). Thus, VT is an appropriate method for many individuals to predict their ability to sustain work. Recent evidence from the HERITAGE Family Study and others also suggests that VO_2 at VT ($\text{VO}_{2\text{vt}}$) values may help to evaluate if aerobic fitness levels are adequate to maintain health and reduce the risk for cardiovascular disease and diabetes mellitus (Slivka, 2001).

Problem

Several laboratory methods are currently being utilized in order to determine the intensity level at which VT occurs. V-slope, linear regression, Dmax, and CUSUM are popular aids in establishing the point at which ventilation measurements become non-linear. The first break in linearity is commonly known as the ventilatory threshold (VT) and is

generally associated with the first rise in blood lactate seen during a progressive exercise test. Current methods to estimate VT are useful in laboratory research, but difficult to use in the field or during activities of daily living. For large epidemiological studies, or for health screening, it is not practical to obtain laboratory ventilatory data on every individual interested in improving cardiovascular fitness or who might be at risk for cardiovascular disease (CVD). Due to the importance of VT for health and exercise intensity, and in order to assist physicians and researchers alike, a non-invasive, self-report, prediction method for VT would prove very useful. This study examines the ability to predict $\text{VO}_{2\text{vt}}$ using descriptive data and information collected from a short activity questionnaire.

Null Hypothesis

There will be no correlation between activity levels reported on daily activity questionnaires and ventilatory threshold.

Research Hypothesis

Activity levels reported on questionnaires will be significantly related to VT.

Significance

The significance of this study is to assist researchers and physicians in determining sustainable aerobic fitness levels based on self-report questionnaires.

Rationale

The rationale for this study is the importance of developing reliable and valid methods to easily assess VT in order to improve the ability to prescribe exercise training intensity and evaluate the risk for chronic diseases such as diabetes and CVD.

Limitations

Coding: There is an inherent error associated with subjective coding of questionnaires.

Self-report: There is an inherent risk of inaccurate data based on subjective opinion.

Practical Application: The results can only be applied to a similar group of subjects as will be recruited for this study.

Delimitations

Mode: The mode of exercise was limited to walking on a treadmill and may not give accurate VT values for other activities.

Sample size: This will be limited to approximately 70 individuals in a heterogeneous population of both healthy and multiple risk factor individuals of ages 18-80.

Definition of Terms

Ventilatory Threshold: The intensity of exercise at which the ventilatory equivalent for oxygen begins to increase without a corresponding increase in the ventilatory equivalent for carbon dioxide

R: Respiratory gas exchange ratio (VCO_2/VO_2)

VO_{2max} : Maximal volume of oxygen consumed during exercise

V-slope: A graphical plot of VCO_2 vs. VO_2 . VT is the point of onset of the non-linear increase of VCO_2 at an RPE of about 12-14 and an R of approximately .89-.95

CUSUM: Based on an observed increase in the variability of the ventilation data above the ventilatory threshold in a graph of ventilation versus time

Relative Intensity: The intensity of exercise relative to the individual's ventilatory threshold expressed as a percent of VO_2 at VT

Anaerobic threshold: The point during exercise at which lactate production begins to increase exponentially

Dmax: Calculating the point that yields the maximal distance from a curve representing ventilatory and metabolic variables as a function of VO_2 to the line formed by the two endpoints of the curve

Chapter Two

REVIEW OF LITERATURE

Ventilatory threshold prediction methods

The prediction of ventilatory threshold is generally accomplished through the use of one or more of several possible methods. Whether the researchers use graphs to estimate the aerobic/anaerobic breakpoint or a computer linear regression is utilized, VT determination is a subjective process.

Bischoff and Duffin (1995) believe that relying on underlying physiological assumptions is not the most accurate way to determine ventilatory threshold. In order to prove this point, the V-slope method and the CUSUM method, which is based on an increase in the variability of the ventilation data above the VT in a graph of ventilation vs. time, were compared to determinations made by eye. They defined VT as the point at which the first non-linear increase in ventilation occurs. Male subjects (N = 12) performed a total of 47 incremental treadmill exercise tests to exhaustion. Expired gas was analyzed in order to predict VT, and the results were then assessed using each of the three methods mentioned previously. The 12 subjects were divided into a young (23-25 years) and old (53-70) age group and the results were taken after various training and detraining conditions over a period of 5 months. The researchers concluded that the CUSUM method is useful in determining VT using ventilation data alone.

A study by Cheng et. al. (1992) suggests that VT can be predicted by breathing frequency, alone. The initial objective of this project was to determine a different approach to determine ventilatory and lactate thresholds. Using eight trained male cyclists, two incremental cycle ergometer tests were issued two weeks apart. The results were measured using ventilatory and metabolic data and were calculated using the Dmax method. This method consists of calculating the point that yields the maximal distance from a curve representing ventilatory and metabolic variables as a function of VO₂ to the line formed by the two endpoints of the curve. In this study, Dmax was suggested to be an accurate tool useful in determining VT. The results also proved that VT could be determined by ventilatory variables, which is the only respiratory variable that can be easily measured in field tests.

There is a high, positive correlation between a computer linear regression model to determine VT and observations of VT based on researchers' opinions. This was shown in a study by Orr, et. al. (1982). Subjects were college age (N = 37; 23 males and 14 females) and were previously involved in other aerobic investigations. VT was determined from data after subjects completed a graded cycle ergometry test. Researchers compared their observed VT results to a linear regression model generated by a computer. The correlation coefficient for the two methods was .94.

Shimizu et. al. (1991) performed a study that tested the method, protocol, and evaluator agreement on ventilatory threshold. Twenty-three men completed six different exercise protocols involving three treadmill tests and three cycle ergometer tests. The subjects

were divided into a heart disease group (N = 17) and a healthy group (N = 6). The VT was determined for each exercise protocol by trained observers utilizing graphic plots. The results suggest that VT is affected by protocol, method of detection, and reviewer and that these differences should be considered when evaluating ventilatory threshold.

Davis et. al. (1976) completed a study on anaerobic threshold and maximal exercise power using three modes of exercise: arm cranking, cycling, and treadmill walk-running. After testing thirty college-age males on the three exercise modes, both venous blood measurements and gas exchange methods were used to determine Anaerobic Threshold (AT). The researchers concluded that gas exchange LT is a valid and valuable indirect method for the detection of the development of lactic acidosis (AT) during incremental exercise.

Although gas exchange and blood sampling are the methods typically used, researchers are constantly searching for easier ways to predict and estimate ventilatory threshold.

Age, gender, cardiovascular fitness, and VT determination

It is often suggested that as individuals age, overall fitness levels decline. This is often true in regards to VO₂, ventilatory threshold, and other parameters used to evaluate health and fitness.

In order to prove that VT and VO₂ max vary with age, sex, height, and weight, Posner et. al. (1987) conducted a study composed of 171 healthy subjects. The subjects were divided into a predominantly older group (mean age: 68) and young/middle age group (mean age: 39). Subjects completed a two maximal tests on a mechanically braked cycle ergometer and ventilatory data was collected using breath-by-breath measurements collected by a computerized system. The results suggest that age-associated changes in musculature lead to a lesser decline in VT than in the aerobic-anaerobic reserve.

A study performed at the University of Montana (Slivka, 2001) was conducted in order to develop submaximal exercise protocols to estimate the ventilation of O₂ (VO₂) and HR at the ventilatory threshold. Both a healthy, college aged population (N = 55) and an at-risk population possessing 2 or more risk factors for coronary artery disease (N = 26) were studied. The healthy group performed a graded treadmill test and the at-risk group completed a 3-minute bench step test in order for the researchers to predict VO₂vt. The linear relationship between HR and VO₂ was used to estimate HRvt. The researchers' data suggests that, in both groups, it is possible to predict VO₂vt and HRvt using submaximal testing.

A study conducted by Meyer, et al. (1996) tested normal individuals (N = 69), coronary patients with myocardial ischemia (N = 27), and patients with chronic heart failure (N = 33) in order to observe differences in ventilatory threshold measures. The V-slope, ventilatory equivalent for oxygen, gas exchange ratio(R), and end-tidal partial pressure of oxygen were the four methods used in this experiment. Subjects performed both

ramp-like and graded steady state exercises on a cycle ergometer and researchers used the aforementioned methods to determine ventilatory thresholds. Findings show that VT is easier to determine in healthy people as opposed to patients with CHF, unless a V-slope method is utilized.

Davis, et. al. (1997) developed lactate threshold prediction equations with cross validation. Two hundred and four individuals (N = 203; 101 females and 103 males) underwent graded exercise testing on a cycle ergometer. All subjects were healthy, non-smoking, sedentary individuals. The V-slope method was used to detect LT and multiple linear regressions were assessed to develop 8 gender specific and 4 generalized equations taking age, height, body mass, and fat-free mass into account. The results suggest that in non-obese individuals, gender specific formulas are accurate tools to predict LT.

The importance of testing VT on individuals at risk for CVD and diabetes is often overlooked. . In general, most studies focus on healthy populations when conducting VT testing. Studies suggest that cardiovascular health, more than age or gender, is an issue when determining VT. It is important to develop prediction equations that encompass both healthy and at-risk individuals. This study should help to identify methods to predict VT in at-risk individuals.

Training mode and intensity in relation to VT

In general, cardiovascular activity performed several days per week for 30 minutes is recommended to obtain aerobic fitness, but there is a minimal intensity at which subjects must work in order to see marked improvements in cardiovascular fitness. Working at or above the intensity associated with ventilatory threshold is suggested by the following studies in order to improve cardiorespiratory fitness

An exercise program below the intensity of VT may be inadequate stimulus to alter the ventilatory threshold in patients with coronary heart disease. Additionally, changes in VT do not necessarily explain increased treadmill time at low intensities (Sullivan et. al. 1985). However, a significant correlation was found between the absolute change in peak VO₂ and the absolute change in VO₂ at VT. Forty-one subjects with coronary heart disease were observed over a year long time period. The subjects were participants in an exercise program for CHD patients. The experimental group was involved in monitored exercise that consisted of 30-45 minutes of cardiovascular work, four to five times a week. A control group was given a set of guidelines for home-based activities. Gas analysis was used to determine VT both before and after training. Results of the study suggest that exercise must be performed above VT in order to increase other cardiorespiratory variables including peak VO₂ and VT.

Hill (1987) concluded that RPE at VT isn't affected by training. This finding was determined by dividing college-aged students ($N = 27$) into a control and an experimental group, with the experimental group completing 18 interval-training sessions on a cycle ergometer. Pre and post training variables (cardiorespiratory, metabolic, and perceptual) were measured during graded exercise tests on a cycle ergometer. Post training results were then analyzed using an ANCOVA, with pre training values used as covariates. Although the experimental group subjects improved VO_2 at VT, their RPE at VT did not change.

Reybrouck et. al. (1986) conducted a study consisting of eleven healthy males in order to evaluate maximal endurance performance based on the ventilatory threshold. The subjects first completed either a Balke treadmill test (untrained subjects) or the Taylor treadmill test (trained subjects) and ventilatory data was collected using a metabolic system. Three separate treadmill tests were conducted during this study. This initial test utilizing a Balke treadmill test was conducted in order to determine VO_2 max. A second set of tests were conducted to get an estimate of VT during short-term exercise using either the modified Balke or the Taylor treadmill test, depending on the subjects' VO_2 max. Finally, a third test was performed in order to predict VT during long-term exercise based on data collected during a ten-minute treadmill run. Based on their findings, the researchers concluded that VT during long-term exercise predicts maximal endurance performance better than the threshold measured for short-term exercise or VO_2 max. This experiment was conducted to investigate past research that suggests that when

exercise intensity is prolonged, a second threshold is reached where ventilatory and metabolic variables reach a steady state.

METHODOLOGY

Setting

Initial testing was conducted at Southgate Mall in conjunction with Community Hospital's Health Fair. The final testing was conducted at New Directions Therapy Clinic.

Subjects

Sixty-three recreationally active adults were tested. Twenty-eight males (43.75±21.12 yrs, 28.44 ±8.2 BMI) and thirty-five females (41.35±20.11 yrs, 25.22±4.05 BMI) were tested. They were recruited from the aforementioned Health Fair.

Descriptive Data

A consent form approved by the IRB at the University of Montana was created to explain the risks and procedures of the testing. Prior to actual laboratory ventilatory threshold testing, subjects' age, height, weight, and current activity level were obtained from an activity questionnaire. The activity questionnaire is an updated version of the *University of Houston Non-Exercise Test*, and modified by Gaskill et. al. It is designed to estimate exercise duration, frequency, and intensity. Blood pressure testing was conducted at the health fair and was recorded onto the activity questionnaire by the subject.

Exercise Testing

A modified Balke treadmill protocol was used for the laboratory measurement of VT. A warm up consisted of walking three to five minutes at a low intensity, self selected pace with no incline. The treadmill test consisted of continuous self-selected walking speed with an initial grade of 0% that increased 1% every minute. A Parvo Medics metabolic cart (Salt Lake City, UT) was used to collect expired gasses during the testing. The cart

was calibrated both before and after each exercise session with known concentrations of O₂ and CO₂. Flow rate was calibrated using a 3 liter syringe. EKG data was collected and recorded using a Physio-control Lifepack 12 portable defibrillator (Redmond, WA). Limb leads, V₂, and V₅ were used to assess heart rhythms. Each minute, HR and RPE were collected during the final ten seconds. When RER > 1.02, HR > 85% age predicted max heart rate (220-age), and/or RPE > 15, the testing was terminated. These results are typical of exercise intensities at 120% of VT and suggest that the subject had exceeded VT. Following the exercise bout, a five-minute cool down walk was performed at a self-selected, low intensity cadence with a 0% grade. 12 lead EKG tracings were obtained at rest before testing, once during exercise, and immediately post exercise for individuals with multiple risk factors. Metabolic data collected during the exercise test was downloaded to a spreadsheet and a macro was used to print graphs for visual VT determination. The graphs include plots of ventilatory equivalent, V-slope, and excess CO₂ methods. RER and RPE data were also evaluated in order to more accurately predict VT. Two separate investigators picked VT independently and if agreement wasn't reached, the subject was eliminated from the data set or retested when possible.

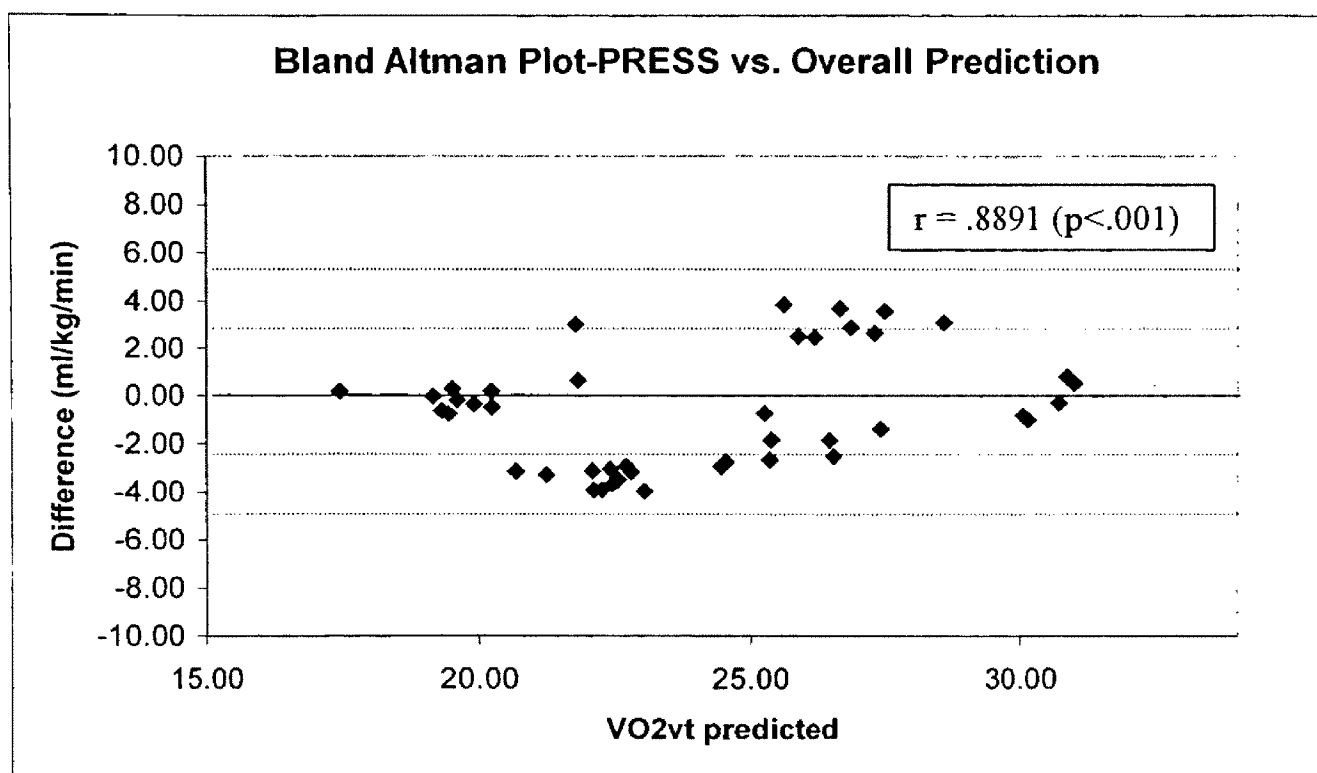
At the time of the laboratory testing subjects were again asked to complete the activity questionnaire, which was modified from *University of Houston Non-Exercise Test*. During the lab visit, the questionnaire was completed during an interview process. Modifications were added to allow for better estimation of intensity of exercise.

Research Design and Statistical Procedures

A stepwise multiple regression was used to analyze the data ($p > .05$) to determine those factors from the activity questionnaire most related to VT and to develop a regression

equation to estimate VT. The rejection level was set at $R = 0.15$. Statistical calculations were performed using GBstats software and further analyses was made using SAS statistical software. Cross validation of the multiple regression formula was implemented using a Bland-Altman plot.

Figure 1.



The Bland-Altman plot showing the difference between the individual PRESS-cross validation VO₂vt and the predicted VO₂vt using the overall multiple regression model. The average difference between the PRESS-cross validation VO₂vt and the predicted VO₂vt using the overall multiple regression model was -0.657. Forty-four percent of the data fall within one standard deviation, and 100% fall between two standard deviations. The dotted lines represent one and two standard deviations.

Table 1. Descriptive characteristics (mean \pm standard deviation)

	N	Age (years)	Height (cm)	Weight (kg)	BMI
Total group	63	42.11 \pm 20.43	171.75 \pm 11.95	76.24 \pm 17.39	26.11 \pm 6.52
Low Fit	36	58.18 \pm 13.47	171.25 \pm 10.18	78.72 \pm 19.16	25.58 \pm 4.78
High Fit	27	23.23 \pm 5.39	171.09 \pm 13.87	73.43 \pm 14.88	25.54 \pm 8.02
Males	28	43.75 \pm 21.12	178.35 \pm 16.16	88.70 \pm 15.66	28.44 \pm 8.2
Females	35	41.35 \pm 20.11	165.59 \pm 7.08	66.55 \pm 11.51	25.22 \pm 4.05

Multiple Regression Equations to predict Ventilatory Threshold in Total Group:

Equations 1-5 show the multiple regression equations for ventilatory threshold developed using stepwise multiple regression analysis on the GBstats software. Further statistical equations were performed using SAS software.

Equation 1: Total group treadmill test. $R = .5057$ $R^2 = .2557$

$$VT = (-.063248 * \text{age}) + (2.191875 * \text{gender}) + (-.049599 * \text{BMI}) + (.205553 * \text{predicted VT}) + 20.870173$$

- Age = years
 - Gender = (1=males, 2=females)
 - BMI = Body mass index (weight in kg/ height in meter²)
 - Predicted VT = Predicted ventilatory threshold (based on sustainable fitness questionnaire coding)
-

Equation 2: Group A treadmill test. $R = .7067$ $R^2 = .4994$

$$VT = (.061922 * \text{age}) + (3.258274 * \text{gender}) + (-1.021066 * \text{BMI}) + (-.02642 * \text{predicted VT}) + 40.845588$$

- Age = years
- Gender = (1=males, 2=females)
- BMI = Body mass index (weight in kg/height in meters²)
- Predicted VT = Predicted ventilatory threshold (based on sustainable fitness questionnaire coding)

Equation 3: Group B treadmill test. $R = .6104$ $R^2 = .3726$

$$VT = (.076049 * \text{age}) + (-.474374 * \text{gender}) + (.19841 * \text{BMI}) + (.588745 * \text{predicted VT}) + 3.144602$$

- Age = years
 - Gender = (1=males, 2=females)
 - BMI = Body mass index (weight in kg/height in meters²)
 - Predicted VT = Predicted ventilatory threshold (based on sustainable fitness questionnaire coding)
-

Equation 4: Female only treadmill test. $R = .5417$ $R^2 = .2934$

$$VT = (.062735 * \text{age}) + (-.739509 * \text{BMI}) + (.205863 * \text{predicted VT}) + 36.840489$$

- Age = years
 - BMI = Body mass index (weight in kg/height in meters²)
 - Predicted VT = Predicted ventilatory threshold (based on sustainable fitness questionnaire coding)
-

Equation 5: Male only treadmill test. $R = .651$ $R^2 = .4348$

$$VT = (-.167874 * \text{age}) + (.080293 * \text{BMI}) + (.170189 * \text{predicted VT}) + 24.848336$$

- Age = years
- BMI = Body mass index *weight in kg/height in meters²)
- Predicted VT = Predicted ventilatory threshold (based on sustainable fitness questionnaire coding)

Chapter Four: Manuscript

The Utilization of Self-Report Questionnaires to Predict Ventilatory Threshold

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Running Title: The Utilization of Self-Report Questionnaires to Predict Ventilatory Threshold

ABSTRACT: PURPOSE: The purpose of this project was to predict VO_2 at the ventilatory threshold ($\text{VO}_{2\text{vt}}$) based on sustainable fitness data collected from self-report questionnaires. Equations to predict $\text{VO}_{2\text{vt}}$ were developed based on descriptive data and reported intensity of sustained exercise. **METHODS:** Male and female subjects ($N=63$) each completed a Sustainable Fitness Questionnaire, compiled at the University of Montana, to estimate average exercise expenditures. A graded treadmill test with collection of metabolic gases was used to determine ventilatory threshold. During the treadmill tests subjects walked at a constant self-selected speed and the treadmill grade was increased one percent each minute. HR and RPE were collected each minute. Following testing, the questionnaires were coded using the Compendium of Physical Activities and maximal sustained VO_2 during exercise ($\text{VO}_{2\text{sustained}}$) was estimated based on these results. Stepwise multiple regression models were used to develop prediction equations for $\text{VO}_{2\text{vt}}$. Cross validation was completed using the Press cross validation method. **RESULTS:** Sixty-three subjects with adequate determination of VT were analyzed. When the group was analyzed as a whole, gender and $\text{VO}_{2\text{sustained}}$ were significant at the $p < 0.01$ level when added to the stepwise regression model ($R^2=0.4934$). When multiple regression analysis was completed by gender the results were improved for the males ($R^2=0.6260$), but was not improved for the females ($R^2=0.4950$). Separation by fitness level improved the predictive ability of the models. For the lower fit group, both BMI and gender were added to the model ($R^2=0.6742$), for the higher fit group, BMI and maximal sustained VO_2 of reported activity levels were added to the model ($R^2=0.7338$). **CONCLUSIONS:** These data show that gender and $\text{VO}_{2\text{sustained}}$ are significant predictors of $\text{VO}_{2\text{vt}}$ when analyzing diverse populations. When multiple regression analyses were completed by gender, the results were improved for the males but not the females. Separation by fitness levels also improved the predictive ability of the models. Self reported intensity of activity improves the prediction of $\text{VO}_{2\text{vt}}$, especially in more fit individuals.

Keywords: Physical activity, Multiple Regression Equations

Introduction:

Perceived exertion is the single best indicator of the degree of physical strain (Borg, 1982). Subjects' perceived exertion during exercise is typically closely matched with exercise intensities measured by gas exchange methods. Although $\text{VO}_{2\text{max}}$ has been used extensively in research and exercise prescription, ventilatory threshold (VT) is rapidly becoming a more widely accepted method to evaluate cardiovascular fitness as a point from which to prescribe aerobic exercise (Reybrouck, 1986; Tamai, 1993; Londeree, 1997).

McArdle, et al. has shown that the maximal intensity of aerobic exercise that can be sustained for an extended duration of several hours is just below an individual's VT (McArdle, 1996). VT also appears to be an excellent marker of the intensity of training that is sustained during an aerobic training program. Recent evidence also suggests that VO_2 at VT ($\text{VO}_{2\text{vt}}$) values may help to evaluate if an individual's aerobic fitness levels are adequate to maintain health and reduce the risk for cardiovascular disease and diabetes mellitus (Slivka, 2001).

Several laboratory methods are currently being utilized in order to determine the intensity level at which VT occurs. V-slope, linear regression, Dmax, and CUSUM are popular aids in establishing the point at which ventilation measurements become non-linear. The first break in linearity in the V-slope, excess CO_2 and ventilatory equivalents methods is commonly known as the ventilatory threshold. VT is generally associated with the first rise in blood lactate seen during a progressive exercise test.

Current methods to measure VT are useful in laboratory research, but difficult to use in the field or during activities of daily living. For large epidemiological studies, or

for health screening, it is not practical to obtain laboratory metabolic data on every individual interested in improving cardiovascular fitness or who might be at risk for cardiovascular disease (CVD). Due to the importance of VT for health and exercise intensity, and in order to assist physicians and researchers alike, a non-invasive, self-report, prediction method for VT would prove very useful. This study examines the ability to predict $\text{VO}_{2\text{vt}}$ using descriptive data and information collected from a short activity questionnaire.

Methods:

Subjects

Sixty-three adults were evaluated for VT at our testing center. Thirty-six older adults, including 18 males ($60.2 \text{ yrs} \pm 13.6$) and 18 females ($56.6 \text{ yrs} \pm 12.5$), were recruited from a public health screening program at a local shopping mall. An additional 27 young adults, including 14 males ($24.9 \pm 6.7 \text{ yrs}$) and 13 females ($21.1 \pm 1.7 \text{ yrs}$) were recruited from the Health and Human Performance Department at the University of Montana. Descriptive data for the entire cohort and by group are shown in Table 1.

(Proposed site for Table 1)

Activity questionnaire

During the visit to the laboratory, a consent form, approved by the IRB at the University of Montana, was read and signed by all subjects prior to participation. Prior to the start of metabolic testing, subjects completed an activity questionnaire which included age and gender (Figure 1). Height and weight were measured following completion of the activity questionnaire. **(Proposed site for Figure 1)**

The activity questionnaire used in this study is a revised version of the *University of Houston Non-Exercise Test* (Ainsworth et al, 2000), which we modified in an attempt to better evaluate exercise intensity. Subjects were asked to complete the sustainable activity questionnaire on which they reported mode, duration, frequency, and intensity of exercise of common activities. The activities were later coded to estimate VO_2 of reported sustained activities ($\text{VO}_{2\text{sustained}}$). Coding was accomplished by assigning MET levels to each recorded activity based on the subjects' reported intensity levels using the Compendium of Physical Activities (Ross et al, 1997). When actual intensity was not recorded but entered only as easy, moderate or hard, the Compendium of Physical Activities was again used to estimate MET levels.

Exercise Testing

A modified Balke treadmill protocol was used for the laboratory measurement of VT. Subjects warmed-up by walking three to five minutes at a self-selected, low-intensity, pace with no incline. After the warm-up the treadmill test consisted of continuous self-selected walking speed with an initial grade of 0% that increased 1% every minute. The younger group performed the same treadmill test, but the speed was set at 4 mph (107.2 m/min). A Parvo Medics metabolic cart (Salt Lake City, UT) was used to collect expired gasses during the testing. The cart was calibrated both before and after each exercise session with known concentrations of O_2 and CO_2 and all data were corrected for post-calibration drift when necessary. Flow rate was calibrated using a 3-liter syringe with calibration over the range of expected ventilation rates.

For the older group, EKGs were continuously monitored using a Physio-control Lifepack 12 portable defibrillator (Redmond, WA). Limb leads, V2, and V5 were used to

assess heart rhythms. For the older group HR values were determined from the EKG tracing while the younger group wore Polar HR monitors (Port Washington, NY). HR and ratings of perceived exertion (RPE) were monitored continuously and recorded during the final ten seconds of each 1-minute stage.

Tests were continued until subjects reached an $\text{RER} > 1.02$, $\text{HR} > 85\%$ age predicted max heart rate ($220 - \text{age}$), and $\text{RPE} > 15$. Our performance criteria for determining when VT was exceeded are typical of exercise intensities at 120% of VT. In a few cases we terminated the test without reaching all of the above criteria when we were reasonably sure that the subject had exceeded VT or the subject requested that we stop. Following the exercise session, a five-minute cool down walk was performed at a self-selected, low intensity cadence with a 0% grade.

Metabolic data collected during the exercise test were downloaded to a spreadsheet and a macro was used to print graphs for visual VT determination per the methods of Gaskill et al (Gaskill, 2001). The VT graphs, which were independently evaluated by three researchers, included plots of ventilatory equivalent, V-slope, and excess CO_2 methods. RER and RPE data were also evaluated in order to more accurately predict VT. If the independent investigators didn't reach agreement on $\text{VO}_{2\text{vt}}$, the subject was eliminated from the data set or retested when possible.

Results:

Seventy-four subjects completed the testing. Sixty-three were used for the analysis after VT was adequately determined and nine were rejected when consensus on VT could not be reached. Simple correlations were performed comparing age, gender, BMI, and $\text{VO}_{2\text{sustained}}$. When compared to measured VT, gender and $\text{VO}_{2\text{sustained}}$ were

positively correlated while age and BMI were inversely correlated to $\text{VO}_{2\text{vt}}$. Data is shown in Table 2.

(Proposed site for Table 2)

Stepwise multiple regression analyses (SAS version 7.0) were performed to determine which independent variables best predict laboratory measurements of $\text{VO}_{2\text{vt}}$. Independent variables included in the regression model were age, gender, body mass index (BMI), $\text{VO}_{2\text{sustained}}$, and meeting or not meeting the Surgeon General's exercise recommendations for health. The stepwise rejection level was set at $p < 0.15$ and significance was set at $p < 0.05$.

When the group was analyzed as a whole, gender and $\text{VO}_{2\text{sustained}}$ were the only two significant variables when added to the stepwise regression (Overall $\text{VO}_{2\text{vt}} = 2.626683 * \text{gender} + 0.292213 * \text{VO}_{2\text{sustained}} + 14.044881$, $R=0.4935$). When multiple regression analysis was completed by gender the results were improved for the males (Male $\text{VO}_{2\text{vt}} = -0.246888 * \text{age} + 34.934347$, $R=0.6260$), but was not improved for the females (Female $\text{VO}_{2\text{vt}} = -0.7272 * \text{BMI} + 47.564349$, $R=0.4950$). Separation by fitness level improved the predictive ability of the models. For the lower fit group, BMI and gender were added to the model (Low fit $\text{VO}_{2\text{vt}} = -0.968257 * \text{BMI} + 3.259975 * \text{gender} + 50.352551$, $R = 0.6742$). For the higher fit group, $\text{VO}_{2\text{sustained}}$ and BMI were added to the model (High fit $\text{VO}_{2\text{vt}} = 0.579021 * \text{VO}_{2\text{sustained}} + 0.207707 * \text{BMI} + 4.278847$, $R = 0.7338$). Standard errors of the estimate ranged from 2.92 to 6.98 $\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$. The regression data are summarized in Table 3 and shown graphically in Figures 2 a-e.

(Proposed site for Table 3 and Figure 2 a-e)

Cross validation of the multiple regression formula was implemented using the PRESS-cross validation method applied to the overall model (Holiday, et al., 1995). This statistical method involves cross-validation of the data set and is achieved by removing one subject at a time from the data set and running a multiple regression. After each multiple regression is run, a correlation between each subjects $\text{VO}_{2\text{vt}}$ and the actual equation is produced.

The PRESS correlation was run on 50 randomly selected subjects. The correlation of predicted $\text{VO}_{2\text{vt}}$ for each subject individually estimated using the PRESS method, compared to the predicted $\text{VO}_{2\text{vt}}$ using the overall equation was $R = 0.8851$. Standard error of the estimate was calculated as -0.01 ± 2.40 when comparing actual vs. predicted ventilatory threshold for the overall group using the PRESS-cross validation method.

A Bland-Altman plot to compare the Press validation data with the data from the overall regression formula is shown in Figure 3. The Bland-Altman plots show that the majority of the cross validation values are less than the standard error of estimate of any of the individual models and are generally within $\pm 5 \text{ ml/kg/min}$.

(Proposed site for Figure 3)

DISCUSSION:

VT appears to be an excellent marker of the intensity of training that is sustained during an aerobic training program (Slivka, 2001). In addition several recent studies have focused on the use of VT as an indicator of sustainable aerobic fitness (Reybrouck, 1983, Cunningham, 1985; Tamai, 1993; Gaskill, 2001). These studies suggest that VT is an appropriate method for many individuals to predict their ability to sustain work.

Recent evidence also suggests that VO_2 at VT ($\text{VO}_{2\text{vt}}$) values may help to evaluate if aerobic fitness levels are adequate to maintain health and reduce the risk for cardiovascular disease and diabetes mellitus (Slivka, 2001).

Ventilatory threshold testing is an applicable exercise measurement from which the general population can benefit. VT measurement currently is done in a laboratory setting using a metabolic cart to collect expired gasses which are then analyzed for a changes in the linearity with increasing work loads. The current data suggest that it is possible to estimate VT using data obtained from descriptive measurements and self-reported activities.

This study focused on a subject set that consisted of two fairly homogenous groups. A low fit group of mainly older adults were taken through the questionnaire process step-by-step. The more-fit group, comprised of younger adults, completed the questionnaire without direct supervision. Although the low fit group completed the questionnaires more accurately and more completely, the higher fit group appeared to be better at estimating their exercise intensities when reporting the speed and amount of exercise exertion. This better estimation of exercise intensity may have been because they have had more exposure to, and information about, exercise intensity and generally participate more regularly in physical exercise than do the older individuals.

The perception of exercise intensity reported by the younger population more closely matched the metabolic data collected during the treadmill test, suggesting that this group has a better perception of exercise intensity, which possibly led to more accurate questionnaire answers. The higher fit group were thus more apt to know and report exact

exercise intensities, such as speed, watts, METS, etc which resulted in better intensity data to predict $\text{VO}_{2\text{vt}}$.

Gender, BMI, age, maximal estimated VO_2 of sustained activities ($\text{VO}_{2\text{sustained}}$), and if individuals met the Surgeon General's exercise recommendation for health, were evaluated to develop equations for VT predictions. Simple correlations of the independent variable with $\text{VO}_{2\text{vt}}$ suggested that gender and $\text{VO}_{2\text{sustained}}$ were positively correlated. This reasonable simple correlation of 0.4387 between $\text{VO}_{2\text{vt}}$ and $\text{VO}_{2\text{sustained}}$ suggests that as activity questionnaires are improved they may become even more useful tools to predict $\text{VO}_{2\text{vt}}$.

Meeting the Surgeon General's exercise recommendations for health did not enter into any of the prediction equations and was poorly correlated to $\text{VO}_{2\text{vt}}$. This is not surprising due to the vague nature of the recommendation. The Surgeon General suggests that exercise should occur most days of the week at a moderate intensity. This list of activities includes exercising at a level that is sufficient to expend about 150-400 calories of energy per day over a wide range of MET levels and appears to be a poor predictor of $\text{VO}_{2\text{vt}}$.

Figure 2 shows the relationship between measured $\text{VO}_{2\text{vt}}$ and predicted $\text{VO}_{2\text{vt}}$ for each of the models (overall, by gender and by fitness group). In all cases, the equations tend to overestimate $\text{VO}_{2\text{vt}}$ for individuals with lower $\text{VO}_{2\text{vt}}$ values and to underestimate individuals with higher $\text{VO}_{2\text{vt}}$ values, thus reducing the range of values in the estimates while maintaining similar $\text{VO}_{2\text{vt}}$ averages. This underestimation of the lower fit is probably due to both the nature of the questionnaire that lumps walking into only three categories of slower, similar to, or faster than most individuals, and to the tendency of

lower fit individuals to over report the intensity of activities. Likewise, the questionnaire does not yet accurately tease out higher intensities of exercise unless individuals know actual running, walking or cycling speeds. This was evidenced by the best multiple R value in the higher fit group where many of the individuals were able to report actual running and cycling speeds. Proposed revisions to the activity questionnaire (Figure 4) may help to answer intensity questions in future studies.

(Proposed site for Figure 4)

Another possible error contributing to the estimation error could be in the duration of activities. There are no reports in the literature suggesting the duration of activity necessary to improve VT. Data from the HERITAGE Family Study (Gaskill, 2001) show that VT after 20 weeks of training 3 times a week for 50 minutes resulted in VO_{2vt} values strongly related ($R > 0.84$) to the VO_2 cost of the cycle training. However many individuals may be reporting activities which they do infrequently. Further analysis may find that there is some critical duration necessary for VO_{2vt} to respond to the increased intensity of the activity.

The results of this study suggest that estimated VO_{2vt} is generally overestimated at low intensities and underestimated at high intensities. These data suggest that the questionnaire needs revision in order allow the subject to provide more specific exercise intensities. The results yield desirable numbers when the exercise intensity is average, but fail to be accurate at intensities that are higher or lower than the mean.

The current research suggests that using both descriptive and activity questionnaire data it is possible to predict VO_{2vt} with a moderate (4-6 ml/kg/min) standard deviation. As activity questionnaires are developed that better detect exercise

intensities, especially in less active populations, it will become possible to reduce the standard deviation of the estimates from 4-6 ml/kg/min to less than 4 ml/kg/min. Future research should include a revised questionnaire to better identify intensity of sustained activities and a larger, more heterogeneous sample population.

It is not always feasible or affordable to test VT in a laboratory setting and researchers are in need of a tool that would allow for quick and easy prediction of ventilatory threshold. Simple activity questionnaires may provide an important tool in estimating $\dot{V}O_{2vt}$ for individuals or in large population studies. This research provides a starting point but it is the belief of the researchers that the questionnaire used in this study appears to be difficult to follow and relies on exercise estimations from the general population. Many older or inactive individuals do not know the exercise intensity at which they work. To facilitate complete and accurate questionnaire results, a more succinct format would be useful.

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Figure Captions:

Figure 1: Sustainable Fitness Questionnaire used in the current research. This questionnaire was extensively modified from the University of Houston Non-Exercise Test (Ainsworth et. al, 2000) in an attempt to better estimate intensity of aerobic activities.

Figure 2: Scatter plots showing actual vs. predicted $\text{VO}_{2\text{vt}}$ for each model; a) overall, b) low fit group, c) high fit group, d) males, and e) females. Note, in general the prediction equations over predict $\text{VO}_{2\text{vt}}$ for the lower fit individuals in each group and under predict $\text{VO}_{2\text{vt}}$ for the higher fit individuals.

Figure 3: Bland Altman plot showing predicted $\text{VO}_{2\text{vt}}$ compared with the difference between the PRESS-cross validation $\text{VO}_{2\text{vt}}$ and the predicted $\text{VO}_{2\text{vt}}$ using the overall regression model. The average difference between the PRESS-cross validation $\text{VO}_{2\text{vt}}$ and the predicted $\text{VO}_{2\text{vt}}$ using the overall regression model was $0.657 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$. The dotted lines on the graph represent one and two standard deviations of the difference in the predicted vs. actual $\text{VO}_{2\text{vt}}$. Forty-four percent of the cross-validated data fell within 1 standard deviation and all fell within two standard deviations. The correlation between the individual $\text{VO}_{2\text{vt}}$ values determined from the PRESS cross-validation and those predicted from the overall regression equation was $r=0.8891$ which suggests a valid prediction model.

Figure 4: Proposed revised Sustainable Fitness Questionnaire. This revision makes the questionnaire easier to follow and complete while improving the potential to better estimate intensity of sustained aerobic activities.

Figure 1.

ID # _____

Sustainable Fitness Questionnaire

This questionnaire will help us to give you feedback to let you know if you are doing adequate physical activities to reduce your risk of Heart Disease. All information is strictly confidential.

PART A:

Do you, on average, walk or do other similar exercises for at least 30 minutes most days of the week?

Yes No

Out of the following sections please circle the numbers that most apply to you.

PART B:

If you participate regularly in physical activity at work or during free time, then skip to PART C.

If you do not participate regularly at work or during free time in regular aerobic (endurance) physical activity, sports or heavy physical activity circle 0 or 1.

0 = Avoid walking or exertion, e.g., normally use the elevator, drive whenever possible instead of walking. → → →

1 = Walk for pleasure, routinely use stairs, occasionally exercise to cause heavy breathing or perspiration. → → →

If you answered 0 or 1, you may stop here.

If you answered '0' or '1' Please circle one of the following:

Compared to individuals your age, when you walk, do you tend to?

- A = Walk slower than most people?
B = Walk about the same speed as most people?
C = Walk faster than most people?

PART C:

If you participate regularly at work or during free time in regular moderate intensity aerobic (endurance) physical activity, such as golf (walking), horseback riding, calisthenics, aerobics, table tennis, bowling, weight lifting, yard work or similar intensity activities (on a regular basis) circle 2, 3 or 4. The times refer to the amount of time each week that you spend doing moderate physical activity.

2 = 10 to 60 minutes per week → → →

3 = 1-3 hours per week → → →

4 = 3+ hours per week → → →

If you also do regular heavy physical activity or do training for fitness please fill in part D on the reverse side.

If you answered '2' or '3' Please circle one of the following:

Compared to individuals your age, when you walk, do you tend to?

- A = Walk slower than most people?
B = Walk about the same speed as most people?
C = Walk faster than most people?

PART D - on back side

Figure 1 cont.

PART D

If you participate regularly in **heavy physical exercise** such as running or jogging, swimming, cycling, rowing, skipping rope, running in place, or engage in vigorous aerobic activity-type exercise such as tennis, basketball, or handball circle the appropriate number below. (Please note that running/jogging is mentioned simply to remind you that if you circle one of the numbers below you are stating time spent in similar intensity aerobic or endurance activities).

How many total minutes per week do you, on average, spend doing activities that are the equivalent in intensity to running or jogging (i.e. - more work than a brisk walk)

_____ min/week

↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓

My typical week includes the following aerobic/endurance activities (include both work and free time):

ACTIVITY	INTENSITY (easy, moderate, hard)	HOURS/WEEK	Office use
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

When I do these activities my perception is that, compared to a healthy college-aged person, I generally tend to do my activities at an intensity that is at:

- _____ a less intense level or speed than most college aged persons.
 _____ about the same level of intensity or speed as most college aged persons.
 _____ a harder, more intense level or speed than most college aged persons.

IF APPROPRIATE, AND IF YOU KNOW THE FOLLOWING, PLEASE ANSWER:

When I run it generally takes me about _____ minutes/mile.

When I run on a treadmill my normal speed is _____ miles/hour.

When I bike it generally takes me about _____ minutes/mile on flat roads.

FILL OUT AS APPROPRIATE

In the fitness center when I use a _____ machine it says my
 (type of exercise machine)

(watts, calories/min, METS, _____) are? _____
 (fill in unit) (fill in value)

Gaskill—Modified University of Houston Non-Exercise Test (pg269-Practical Measurement and Assessment-Truschler) - File = research/MSFIT II/activity questionnaire

Figure 2.

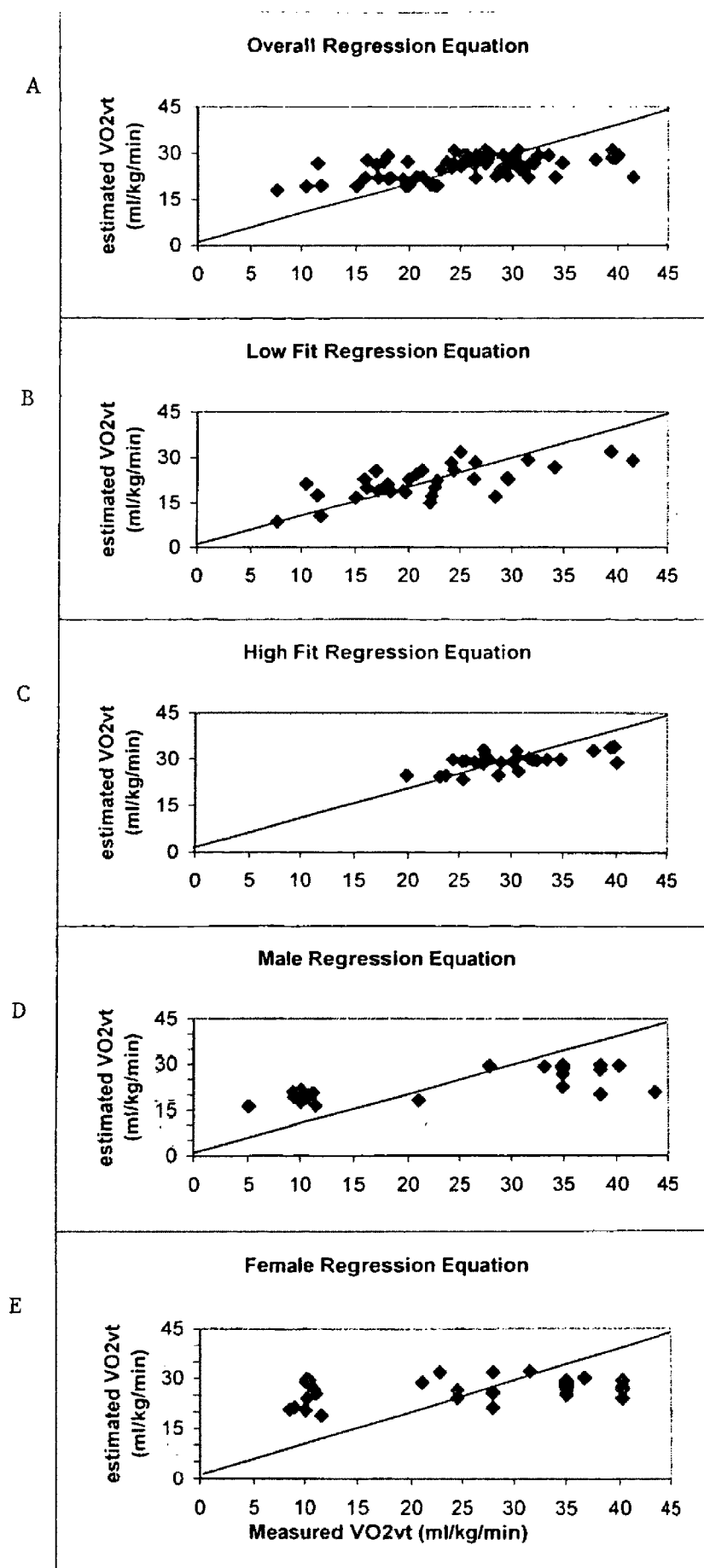


Figure 3.

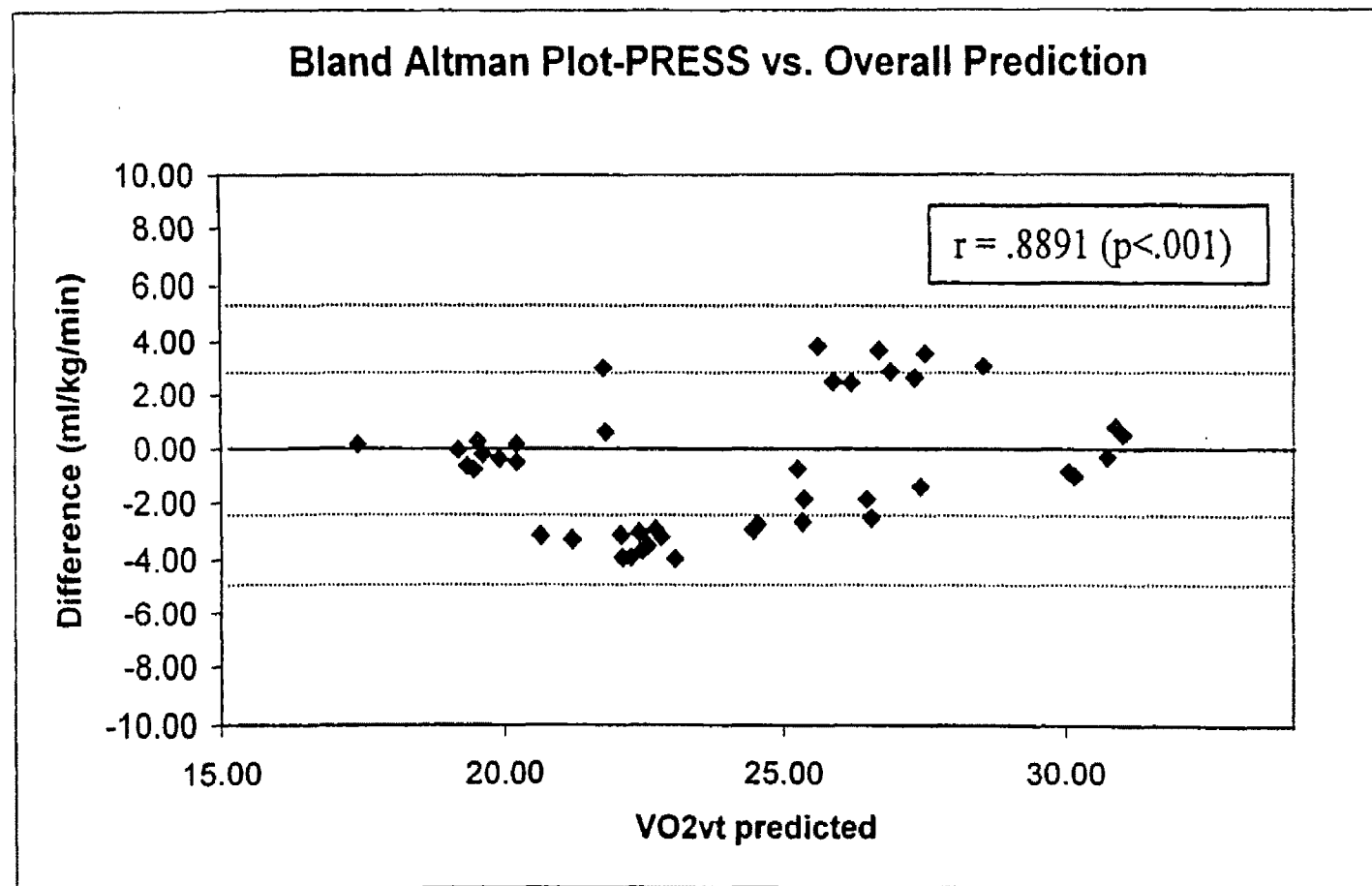


Figure 4.

PROPOSED REVISION FOR
SUSTAINABLE FITNESS QUESTIONNAIRE

ID # _____

This questionnaire will help us to give you feedback to let you know if you are doing adequate physical activities to reduce your risk for Heart Disease. All information is strictly confidential.

1. Do you participate in *moderate* aerobic activity for 30 minutes at least 5 days per week?

YES NO

2. Do you walk for pleasure, routinely use stairs, occasionally exercise to cause heavy breathing or perspiration?

YES NO

3. If you participate in regular *moderate* physical activity at work or during free time, how many hours per week do you do? (Example: calisthenics, walking, weight lifting, etc.)

1-3 hours

4-6 hours

7-9 hours

10 + hours

4. The hardest physical activity that I do on a regular basis is: (please describe the activity and describe how hard you are working in terms of how fast you are going, how long it takes you to go a distance, or any other information that you can give us to help us estimate your energy use during the activity):

ACTIVITY: _____

DESCRIPTION:

Over

Figure 4 cont.

5. If you participate in regular **heavy** physical activity, how many hours per week do you do?

1-3 hours

4-6 hours

7-9 hours

10 + hours

6. If you participate in regular heavy physical activity, please complete the following.

My typical week includes the following **heavy** aerobic/endurance activities:

ACTIVITY	INTENSITY (easy, moderate, hard)	HOURS/WEEK
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

IF APPROPRIATE, AND IF YOU KNOW THE FOLLOWING, PLEASE ANSWER:

When I run my normal speed is _____ miles/hour.

When I run it takes me about _____ minutes/mile

When I bike my normal speed is _____ miles/hour

When I bike it takes me about _____ minutes/mile

Table 1. Descriptive characteristics (mean \pm standard deviation)

	N	Age (years)	Height (cm)	Weight (kg)	BMI
Total group	63	42.11 \pm 20.43	171.75 \pm 11.95	76.24 \pm 17.39	26.11 \pm 6.52
Low Fit	36	58.18 \pm 13.47	171.25 \pm 10.18	78.72 \pm 19.16	25.58 \pm 4.78
High Fit	27	23.23 \pm 5.39	171.09 \pm 13.87	73.43 \pm 14.88	25.54 \pm 8.02
Males	28	43.75 \pm 21.12	178.35 \pm 16.16	88.70 \pm 15.66	28.44 \pm 8.2
Females	35	41.35 \pm 20.11	165.59 \pm 7.08	66.55 \pm 11.51	25.22 \pm 4.05

Table 2 – Simple Correlations: Simple correlations between measured VO_{2vt} and independent variables used in multiple regression models are shown below.

Variable	Measured VO_{2vt}	Significance
Age	-0.439053	P<0.001
Gender	0.1624273	NS
BMI	-0.15244	NS
$VO_{2sustained}$	0.4387	P<0.001

Surgeon General's Guidelines

Table 3

ID#	age	gender	bmi	predVT	actVT	surgen	ID#	age	gender
1	23	1	23.76	33.25	29.66	1.00	1	-0.083750	-0.966595
2	71	1	26.57	10.15	22.56	1.00	2	-0.091555	-0.937485
3	23	2	24.06	40.25	24.40	1.00	3	-0.088956	-0.840208
4	62	2	21.61	21.00	24.18	1.00	4	-0.092691	-1.206161
5	65	2	30.27	28.00	17.55	1.00	5	-0.070599	-0.766493
6	64	1	28.25	9.45	19.69	1.00	6	-0.088955	-1.093456
7	64	1	29.93	9.45	14.55	1.00	7	-0.089379	-1.362150
8	62	2	24.08	10.95	21.30	1.00	8	-0.090035	-1.190423
9	66	1	23.85	10.59	19.97	1.00	9	-0.089076	-1.087819
10	58	2	17.98	22.75	25.09	1.00	10	-0.092284	-1.205496
11	60	2	25.42	11.13	20.73	1.00	11	-0.089394	-1.160426
12	71	1	24.27	10.15	22.77	1.00	12	-0.091704	-0.927117
13	58	1	31.65	11.31	22.08	1.00	13	-0.088238	-1.022896
14	60	2	30.96	10.06	17.04	1.00	14	-0.088718	-1.045823
15	42	2	24.32	24.50	28.19	1.00	15	-0.089127	-1.227448
16	75	1	29.49	11.55	18.23	1.00	16	-0.087856	-1.144856
17	56	2	26.90	24.50	23.18	1.00	17	-0.088493	-1.092505
18	57	1	25.43	43.75	32.18	1.00	18	-0.096499	-1.047471
19	54	2	33.02	11.67	21.26	2.00	19	-0.088601	-1.150601
20	65	2	22.94	10.68	22.66	1.00	20	-0.091910	-1.257203
21	53	2	27.10	10.24	17.69	1.00	21	-0.089983	-1.051563
22	33	2	21.37	10.06	19.26	1.00	22	-0.094517	-1.066888
23	55	2	31.39	10.09	18.22	1.00	23	-0.089367	-1.073252
24	54	2	20.45	10.16	24.89	1.00	24	-0.086507	-1.273303
25	60	1	26.60	38.50	22.97	1.00	25	-0.070727	-1.283883
26	68	1	23.23	21.00	23.19	1.00	26	-0.090152	-1.079802
27	70	2	30.16	9.02	13.81	1.00	27	-0.084964	-0.957491
28	33	1	29.18	35.00	21.02	1.00	28	-0.090455	-1.521152
29	68	2	20.81	10.45	19.18	2.00	29	-0.089897	-1.142450
30	76	1	38.28	5.06	11.99	2.00	30	-0.085756	-1.362604
31	76	2	31.00	8.49	10.85	2.00	31	-0.079068	-0.847231
32	57	1	25.39	9.34	23.06	1.00	32	-0.086473	-0.934357
33	65	2	17.83	31.50	29.34	1.00	33	-0.104990	-1.379778
36	23	2	27.11	40.25	39.48	1.00	36	-0.089001	-1.437517
37	24	1	25.48	35.00	24.43	1.00	37	-0.095747	-1.432743
39	21	2	20.93	20.93	20.93	1.00	39	-0.101048	-1.004473
40	22	2	23.12	40.25	27.43	1.00	40	-0.089358	-0.958686
41	22	1	28.00	40.25	39.84	1.00	41	-0.083907	-0.730562
42	23	1	25.84	28.00	28.85	1.00	42	-0.084490	-1.091676
43	23	1	32.11	28.00	30.75	1.00	43	-0.084498	-0.977216
45	21	1	64.52	14.61	37.86	1.00	45	-0.089525	-1.084883
48	21	2	22.99	35.00	25.32	1.00	48	-0.088028	-1.405247
50	21	2	20.96	35.00	29.09	1.00	50	-0.087775	-1.348631

Table 3 continued

predVT	constant	act VT	ind VT	oa VT	pred	diff 1
0.303167	22.78	29.66	29.96746	27.32		-0.31
0.301549	23.10	22.56	18.72182	19.33		3.83
0.315092	22.74	24.40	31.69605	30.88		-7.29
0.293668	23.79	24.18	21.79786	24.54		2.38
0.32455500	21.56	17.55	24.52562	25.25		-6.98
0.29817200	23.38	19.69	19.41083	19.60		0.28
0.28706900	24.18	14.55	19.81009	19.52		-5.26
0.30016600	23.49	21.30	18.81396	22.46		2.49
0.29822000	23.37	19.97	19.56228	19.91		0.41
0.29358900	23.77	25.09	22.68569	25.34		2.41
0.29958500	23.44	20.73	19.08965	22.57		1.64
0.30179000	23.08	22.77	18.70403	19.45		4.07
0.30127400	23.14	22.08	20.40606	20.21		1.67
0.29475200	23.41	17.04	18.95967	22.08		-1.92
0.29642400	23.57	28.19	24.63416	26.48		3.55
0.29742800	23.45	18.23	19.15124	19.18		-0.93
0.29824000	23.36	23.18	23.52626	25.37		-0.34
0.28227700	23.97	32.18	29.7717	26.89		2.41
0.30014600	23.38	21.26	19.7956	22.71		1.46
0.30088200	23.63	22.66	18.35563	22.26		4.30
0.29324600	23.51	17.69	19.63917	22.80		-1.95
0.28734500	23.89	19.26	21.52888	24.46		-2.27
0.29525800	23.46	18.22	19.3781	22.42		-1.15
0.30998200	23.17	24.89	19.10256	23.06		5.78
0.33196500	22.20	22.97	29.45315	25.60		-6.48
0.29649400	23.44	23.19	22.45624	21.82		0.73
0.29497500	23.14	13.81	17.93824	21.22		-4.12
0.30999600	24.03	21.02	30.37369	26.68		-9.35
0.29808700	23.49	19.18	18.20696	22.11		0.97
0.28742300	24.01	11.99	17.58449	17.40		-5.59
0.29691500	22.70	10.85	17.51754	20.65		-6.66
0.30693500	22.75	23.06	19.75425	20.22		3.31
0.27225700	25.06	29.34	24.05219	26.56		5.29
0.27595300	24.26	39.48	30.44505	30.72		9.04
0.29966700	24.32	24.43	31.07767	27.50		-6.65
0.28239000	24.26	20.93	26.04067	27.43		-5.11
0.30700700	23.06	27.43	31.53378	31.00		-4.11
0.28542300	22.71	39.84	31.62176	28.53		8.21
0.29807800	23.35	28.85	28.66124	26.20		0.19
0.30155100	22.87	30.75	28.39276	25.88		2.36
0.29815700	23.41	37.86	24.80208	21.78		13.06
0.28030200	24.08	25.32	29.23149	30.06		-3.91
0.27637700	24.04	29.09	29.17266	30.16		-0.08

average	23.41	23.43	-0.01
sd	6.49	4.93	4.79

Appendix I:
Attachments

Current Regression Summary Table

Dependent Variable: actVT

Multiple R = .6255
 Std Err Est = 6.6287
 F = 16.7119

Ind Var	B Coef	Std Err(B)	t-Value	Prob
AGE	-.246888	.060393	-4.088	.0004

Constant
 34.934347

Current Regression Summary Table

Dependent Variable: actVT

Multiple R = .6463
 Std Err Est = 6.6119
 F = 8.965

Ind Var	B Coef	Std Err(B)	t-Value	Prob
AGE	-.172833	.092034	-1.8779	.0721
estVT	.162124	.152329	1.0643	.2974

Constant
 27.554734

Current Regression Summary Table

Dependent Variable: actVT

Multiple R = .651
 Std Err Est = 6.7124
 F = 5.8845

Ind Var	B Coef	Std Err(B)	t-Value	Prob
-----	-----	-----	-----	-----
AGE	-.167874	.093945	-1.7869	.0866
BMI	.080293	.158469	.5067	.617
estVT	.170189	.155462	1.0947	.2845
Constant				
24.848336				

Current Regression Summary Table

Dependent Variable: actVT

Multiple R = .495
 Std Err Est = 6.1526
 F = 10.7102

Ind Var	B Coef	Std Err(B)	t-Value	Prob
BMI	-.863372	.263815	-3.2726	.0025

Constant
 47.564349

Current Regression Summary Table

Dependent Variable: actVT

Multiple R = .5312
 Std Err Est = 6.0922
 F = 6.2907

Ind Var	B Coef	Std Err(B)	t-Value	Prob
BMI	-.7272	.281823	-2.5803	.0147
estVT	.121895	.094675	1.2875	.2072

Constant
 41.206143

Current Regression Summary Table

Dependent Variable: actVT

Multiple R = .5417
 Std Err Est = 6.1409
 F = 4.2923

GB-STAT V6.5 for MS WINDOWS

04-25-2002

Ind Var	B Coef	Std Err(B)	t-Value	Prob
-----	-----	-----	-----	-----
AGE	.062735	.089218	.7032	.4872
BMI	-.739509	.284615	-2.5983	.0142
estVT	.205863	.152862	1.3467	.1878
Constant				
36.840489				

Current Regression Summary Table

Dependent Variable: actVT

Multiple R = .4625
 Std Err Est = 6.8373
 F = 16.6028

Ind Var	B Coef	Std Err (B)	t-Value	Prob
estVT	.290131	.071204	4.0747	.0001

Constant
 18.183465

Current Regression Summary Table

Dependent Variable: actVT

Multiple R = .4935
 Std Err Est = 6.7631
 F = 9.6573

Ind Var	B Coef	Std Err (B)	t-Value	Prob
Gender	2.626683	1.715071	1.5315	.1309
estVT	.292213	.070444	4.1482	.0001

Constant
 14.044881

Current Regression Summary Table

Dependent Variable: actVT

Multiple R = .5041
 Std Err Est = 6.7721
 F = 6.7012

Ind Var	B Coef	Std Err (B)	t-Value	Prob
-----	-----	-----	-----	-----
AGE	-.062247	.067906	-.9167	.363
Gender	2.404736	1.734342	1.3865	.1708
estVT	.210681	.11352	1.8559	.0685
Constant				
19.072022				

Current Regression Summary Table

Dependent Variable: actVT

Multiple R = .5057
 Std Err Est = 6.8231
 F = 4.9815

Ind Var	B Coef	Std Err (B)	t-Value	Prob
-----	-----	-----	-----	-----
AGE	-.063248	.068477	-.9236	.3595
Gender	2.191875	1.850937	1.1842	.2412
BMI	-.049599	.142225	-.3487	.7286
estVT	.205553	.115316	1.7825	.0799
Constant				
20.870173				

Current Regression Summary Table

Dependent Variable: actVT

Multiple R = .6645
 Std Err Est = 5.836
 F = 25.2969

Ind Var	B Coef	Std Err(B)	t-Value	Prob
BMI	-1.069202	.212582	-5.0296	<.0001
Constant	50.352551			

Current Regression Summary Table

Dependent Variable: actVT

Multiple R = .6951
 Std Err Est = 5.7037
 F = 14.4934

Ind Var	B Coef	Std Err(B)	t-Value	Prob
Gender	3.259975	2.060862	1.5819	.1238
BMI	-.968257	.217341	-4.455	.0001
Constant	42.587742			

Current Regression Summary Table

Dependent Variable: actVT

Multiple R = .706
 Std Err Est = 5.7118
 F = 9.939

Ind Var	B Coef	Std Err(B)	t-Value	Prob
-----	-----	-----	-----	-----
AGE	.072012	.075394	.9551	.3471
Gender	3.367045	2.066826	1.6291	.1138
BMI	-1.004945	.221012	-4.547	<.0001
Constant	39.206604			

Current Regression Summary Table

Dependent Variable: actVT

Multiple R = .7067
 Std Err Est = 5.804
 F = 7.2329

Ind Var	B Coef	Std Err(B)	t-Value	Prob
-----	-----	-----	-----	-----
AGE	.061922	.087958	.704	.487
Gender	3.258274	2.151235	1.5146	.1407
BMI	-1.021066	.234954	-4.3458	.0002
estVT	-.02642	.113158	-.2335	.817
Constant	40.845588			

MONTANA SUBMAXIMAL FITNESS INVENTORY TOOL-Part II
HUMAN PERFORMANCE LABORATORY
Dept of Health and Human Performance
UNIVERSITY OF MONTANA
Missoula, Montana
SUBJECT INFORMATION AND CONSENT FORM

_____ ID# _____ Today's Date: ____/____/____ Participant
(Print Name) Month Day Year

STUDY STAFF:	Co-director Steven Gaskill, Ph.D.	(406) 243-4268	University of Montana
	Co-director James Laskin, Ph.D., PT	(406) 243-4757	University of Montana
	Dustin Slivka, MA	(406) 543-9356	University of Montana
	Erin Riley	(406) 543-5528	University of Montana

All four staff members above will be actively involved in this research.

This consent form may contain words that are new to you. If you read any words that are not clear to you, please ask the person who gave you this form to explain them to you.

PURPOSE OF THE RESEARCH

- You are being asked to take part in a research study comparing physical fitness with risk for heart disease and diabetes.
- You have been chosen as you are between the ages of 18-80 and have 0-4 risk factors for Coronary Arterial Disease (CAD). The potential risk factors are age, high cholesterol, high blood pressure, smoking, a family history or CAD, obesity, controlled diabetes or that you lead a sedentary lifestyle. Uncontrolled diabetics are excluded.
- The purpose of this research study is determining critical values for physical fitness that will show when an individual is at increased risk for heart disease or diabetes. This information will allow us to assess average long-term physical activity as well as to predict exercise intensities that are the most beneficial for maintaining health and fitness.

PROCEDURES

The four researchers listed at the top of this form will be directing all testing. At least listed member, and generally more than one, will be present for all tests. In addition, other staff from New Direction Physical Therapy Clinic and the Dept. of Health and Human Performance at the University of Montana may help with testing from time to time.

We will measure your height and weight and ask you to fill out short forms to assess your risk for CAD. You will be asked to participate in the following activities during one 90-minute visit to either New Directions Clinic or the Human Performance Lab on the University of Montana campus.

- If you are a male older than 45 or a female older than 55, or if you have two or more risk factors for heart disease, we will first apply electrode to allow us to monitor your heart during the exercise tests using an electrocardiogram (ECG) machine. Ten electrodes will be placed on your chest in a private room. Females may request that a female technician place the electrodes.
- A bench stepping exercise (8 inch high bench) or perform recumbent stepping on a NuStep for three minutes. This is at an easy to moderate exercise, but for some individuals may result in slight shortness of breath and heavy or tired legs.
- A submaximal walking test on a treadmill or stepping test on the NuStep lasting approximately 15 minutes during which you will have an apparatus in your mouth to allow us to collect your expired air. Submaximal exercise means that we will stop short of reaching your maximal effort. For this tests you will be asked to do moderate to moderately hard exercise during the last 3-4 minutes and you will reach about 75% or your estimated maximal heart rate. This may cause you to begin to breathe rapidly, create some feelings of shortness of breath, and cause your legs to become somewhat tired. You have the option, at any time of asking that the test be stopped.

- A 20 ml (about 2 tablespoons) blood sample will be taken and analyzed for cholesterol, triglycerides (fat) and blood sugar. If you had this done at the Community Hospital Heart Check or have recently had these measurements made by another lab, you will not need to have your blood drawn again.

During the exercise tests we will be collecting heart rate data from an EKG and asking you to rate how hard you feel you are working. Blood pressure measurements will be taken during rest and exercise. These measures are to ensure that the tests are safe and that there will be no adverse effects from the exercise.

In addition, you will be asked to fill out a questionnaire concerning your normal physical activity levels and height and weight will be measured.

In addition, you agree to release limited medical records. The medical records you agree to release, if available, are limited to blood lipids (total cholesterol, LDL cholesterol, HDL cholesterol, triglycerides) and fasting blood glucose.

LOCATION AND LENGTH OF TIME REQUIRED

The study will take place at two locations. Healthy males younger than 45 or healthy females younger than 55 will be tested at the Laboratory of Health and Human Performance in McGill Hall on the University of Montana campus (First Floor – enter main doors, go straight through lobby, then enter lab via first door to the right.) Males over 45 or females over 55 or individuals with known diabetes, heart disease or more than two risk factors will be tested at New Directions Clinic (1605 Stephens). The session will last for approximately 90 minutes.

PAYMENT

There is no payment for participation

RISKS/DISCOMFORTS

- Mild discomfort may result during and after the exercise. These discomforts include shortness of breath, tired or sore legs, and a dry throat while wearing the mouthpiece during the treadmill test. Muscle soreness after the tests may occur as a result of the exercise, but should not persist.
- Certain changes in body function take place when any person exercises. Some of these changes are normal and others are abnormal. Abnormal changes may occur in blood pressures, heart rate, heart rhythm or extreme shortness of breath. Very rare instances of heart attack have occurred, as with other moderately strenuous exercise activities. Every effort will be made to minimize possible problems by the preliminary evaluation and constant surveillance during testing. Equipment and trained personnel are available to deal with unusual situations should they arise. A trained CPR and defibrillator technician will be on hand at all times. The laboratory has standard emergency procedures should any potential need arise.
- You will be informed of any new findings that may affect your decision to remain in the study.
- You should alert the exercise physiologists immediately if you experience any symptoms, such as chest discomfort, unusual shortness of breath or other abnormal feelings. The exercise physiologist conducting the research will then terminate the test. Guidelines by the American College of Sports Medicine will be followed to determine when a test should be stopped.

BENEFITS OF PARTICIPATING IN THIS STUDY

- There is no promise that you will receive any benefit from taking part in this study.
- The information from these tests will provide you with accurate information about your aerobic fitness status. This information will be sent to your physician.
- You may request a copy of your exercise and resting EKG tracings to share with your doctor and to maintain in your medical files as a baseline (healthy state) document.
- There are no other direct benefits to the participants in the study

CONFIDENTIALITY

- Your records will be kept private and will not be released without your consent except as required by law.
- Only the four researchers listed at the top of this form will have access to the individual data files.
- Your identity will be kept confidential.

- If the results of this study are written in a scientific journal or presented at a scientific meeting, your name will not be used and only group averages will be presented
- Participant's data will not be shared with any other individuals, including a participant's physician, unless the participant makes a specific written request.
- All data, identified only by an anonymous ID #, will be stored in our laboratory.
- Your signed consent form and information sheet will be stored in a locked office separate from the data.

COMPENSATION FOR INJURY

Although we believe that the risk of taking part in this study is minimal, the following liability statement is required in all University of Montana consent forms. *"In the event that you are injured as a result of this research you should individually seek appropriate medical treatment. If the injury is caused by negligence of the University or any of its employees, you may be entitled to reimbursement pursuant to the Comprehensive State Insurance Plan established by the Department of Administration under the authority of M.C.A., Title 2, Chapter 9. In the event of a claim for such injury, further information may be obtained from the University's Claim representative or University Legal Counsel."*

VOLUNTARY PARTICIPATION/WITHDRAWAL

- Your decision to take part in this research study is entirely voluntary.
- You may refuse to take part in or withdraw from the study at any time without penalty or loss of benefits to which you are normally entitled.
- You have the right to leave the study for any reason.
- You have the right to request that an exercise test or any procedure be stopped at any time.

You may be asked to leave the study for any of the following reasons:

- Failure to follow the study investigator's instructions.
- A serious adverse reaction, which may require evaluation.
- The study director/investigator thinks it is in the best interest of your health and welfare
- The study is terminated.

QUESTIONS

- You may wish to discuss this with others before you agree to take part in this study.
- If you have any questions about the research now or during the study contact:
Steven Gaskill Ph.D. (406) 243-4268 or James Laskin P.T., Ph.D. (406) 243-4757.
- If you have any questions regarding your rights as a research subject, you may contact the Chairman of the Independent Board through the Research Office at the University of Montana at (406) 243-6670.

SUBJECT'S STATEMENT OF CONSENT

I have read the above description of this research study. I have been informed of the risks and benefits involved and all my questions have been answered to my satisfaction. Furthermore, I have been assured that a member of the research team will also answer any future questions I may have. I voluntarily agree to take part. I understand I will receive a copy of this consent form.

Printed (Typed) Name of Subject

Subject's Signature

Date

Date Approved by UM IRB 10/30/01
Approval Expires on 10/8/02
James Laskin IRB Chair

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