ABSTRACT

Smaczny, D.M. Relationship between the talk test and ventilatory threshold during stochastic exercise. MS in Adult Fitness/Cardiac Rehabilitation, December 2002, 40pp. (C. Foster)

Previous studies with a variety of populations have demonstrated that the ventilatory threshold is closely associated with the highest exercise intensity at which subjects may speak comfortably, the Talk Test (TT). These studies have all been conducted using incremental exercise sessions rather than stochastic exercise sessions. In this study, the relationship between the TT and ventilatory threshold during stochastic exercise was evaluated. Subjects (N=18) performed incremental exercise with gas exchange to define VT. Following the initial test, subjects performed the same incremental test with the TT (Pledge of Allegiance). The last two tests were 30-minute stochastic exercise sessions with gas exchange and then with the TT. The subjects ability to speak during stochastic exercise matched expected responses relatively well: (vs VO_2 as %VT, 73%), (vs VO_2 at last positive (LP) stage of the TT, 75%), (vs HR at VT, 69%), (vs HR at LP, 66%), (vs B_f at VT, 51%), and (vs B_f at LP, 39%). The results suggest that the TT is a good measure of intensity during stochastic exercise, although not as good as predicted from previous studies based on incremental exercise.

RELATIONSHIP BETWEEN THE TALK TEST
AND VENTILATORY THRESHOLD
DURING STOCHASTIC EXERCISE

A MANUSCRIPT STYLE THESIS PRESENTED

TO

THE GRADUATE FACULTY

UNIVERSITY OF WISCONSIN-LA CROSSE

IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE

MASTER OF SCIENCE DEGREE

BY

DENISE M. SMACZNY

DECEMBER 2002

COLLEGE OF HEALTH, PHYSICAL EDUCATION, RECREATION, AND TEACHER EDUCATION

UNIVERSITY OF WISCONSIN-LA CROSSE

THESIS FINAL ORAL DEFENSE FORM

Candidate Denise M. Smaczny

We recommend acceptance of this thesis in partial fulfillment of this candidate's requirements for the degree:

Master of Science in Adult Fitness/Cardiac Rehabilitation

The candidate has successfully completed the thesis final oral defense.

Signature of Thesis Chairperson	ESS Department	5/22/02 Date
Signature of Committee Member	PT Department	5/22/02 Date
Signature of Committee Member	ESS Department	5/22/02 Date

This thesis is approved by the College of Health, Physical Education, Recreation, and Teacher Education.

Associate Dean, College of HPERTE	10-7-02 Date
Director of University Graduate Studies	10-7-02 Date

ACKNOWLEDGEMENTS

I would first like to thank my thesis chairperson, Dr. Carl Foster, for his drive to be the best chairperson a student could ask for. I appreciate all of his patience and support throughout this project. I feel very privileged to have worked with such a knowledgeable man.

My committee members, Dr. Dennis Fater and Dr. Karen Skemp-Arlt also deserve great thanks. I am grateful for their time and guidance, which helped me complete my thesis project.

A special thanks to my parents, their love, care and support was amazing throughout my graduate school experience. I will always be grateful for the love that I receive everyday from my parents.

To my classmates, my family, and my friends around the world. My life would not be the same without you. The love and happiness that I receive from you will keep me going for a lifetime.

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INTRODUCTION

Healthy People 2010 set two primary objectives for enhancing the health of Americans. These objectives are to increase life expectancy and to eliminate health disparities among different segments of the population (1). Healthy people 2010 objectives emphasize the benefits of exercise on increasing life expectancy and decreasing the risk for disease. These benefits cannot be achieved without regular exercis*

. *requency, duration, intensity, and mode are several characteristics that make up an exercise program. Exercise intensity is the most difficult characteristic to understand and the most difficult for which to provide guidance. Intensity refers to the rate of energy expended while exercising (e.g., how hard one is working). Intensity is usually understood as a relative intensity for each individual and can be identified by several techniques including: ventilatory threshold (VT), anaerobic threshold (AT), percent of maximal heart rate (HRmax), percent of maximal oxygen consumption (VO_2max), rating of perceived exertion (RPE), and more recently, the Talk Test (TT).

Maximal exercise tests are required to identify VO_2max and HRmax. According to the American College of Sports Medicine (ACSM), percentages based on these maximal values represent the standard approach to prescribing intensity for exercise training (2). Ventilatory threshold can be defined without a maximal exercise test, but is fairly expensive and technically demanding to measure directly. Borg's RPE scale is another way to measure intensity. The scale ranges either from 6-20 or 0-10, ranging from minimal to maximal exertion while exercising (2). RPE has been shown to be well related to objective methods of exercise prescription such as % VO_2max or % HRmax (2). About 90% of people can effectively use the RPE method, which is very useful when maximal exercise test results are not available or when outside factors, such as medicines that change the HR response to exercise are imposed after the exercise test is completed.

A newer, subjective, technique for exercise prescription is the TT. Although widely recommended for many years, data regarding the validity of the TT has only recently become available. Brawner and Keteyian (3) were the first to evaluate the TT (e.g., the ability to talk comfortably while exercising) as a subjective method of prescribing exercise intensity. They observed that the TT was a good measure of intensity level because it resulted in exercising within accepted intensity guidelines. ACSM has also recommended using the TT to evaluate exercise intensity (2).

Although the TT has been recommended for the general public, only a few studies have been done to evaluate the validity of the TT. Brawner, Keteyian, et al. (3) and Czaplicki, Keteyian, et al. (4) completed two of the first studies using the TT. These studies found that individuals who could speak comfortably while exercising were exercising within intensities ranging from 60-90% of VO_2max, consistent with ACSM recommendations for exercise intensity (2). Dehart-Beverly, et al. (5) found the use of the TT to be beneficial in gauging exercise intensity in college students. The results of this study also fell within ACSM guidelines for exercise intensity. In this study the ability to "pass" the TT (e.g., to be able to speak comfortably while exercising) was associated with an exercise intensity just below the VT. Individuals who could not speak comfortably when exercising were at an intensity level above the VT. The findings have been replicated in untrained adults (6), stable patients with cardiovascular disease (7) and well trained individuals (8).

Beyond the early studies of Brawner and Keteyian (3) and Czaplicki, et al. (4), the TT has not been evaluated during an exercise training situation. However, it is the everyday experience of many exercisers that their ability to speak during training may come or go with variations in exercise intensity. If VT were a critical determinant of the ability to "pass" the TT, one would predict that varying the exercise intensity above and below the VT would be reflected by the TT results. Accordingly, the purpose of this study is to evaluate the interaction of exercise intensity and the TT during stochastic (alternating hard and easy) exercise.

METHODS

Subjects

Eighteen subjects (9 male, 9 female) volunteered to participate in this study. Prior to testing, each subject completed a health history questionnaire developed by the American Heart Association (AHA) and ACSM (9). All the subjects were classified as regular exercisers in good health and with no known cardiovascular disease. The study was approved by the University of Wisconsin–La Crosse Institutional Review Board for the Protection of Human Subjects. Informed consent was obtained from each subject prior to testing.

<u>Protocol</u>

Each subject performed a total of four exercise tests over a two-week period. During all four exercise tests, heart rate and RPE were measured and recorded. Two maximal exercise tests were performed, one with gas exchange and one without gas exchange, but using the TT. Two additional stochastic exercise tests were performed, one with gas exchange and one using the TT.

During the incremental tests, the relationship between the VT and respiratory compensation threshold (RCT) versus the TT were evaluated as in previous studies (5,6,7,8). During the stochastic exercise tests the exercise intensity was randomly varied in relation to the absolute exercise intensity at that subjects VT. Workloads represented 70, 80, 90, 100, 105, 110 and 115% of the VO_2 at VT were completed for two minutes each, with each workload presented twice. During the last thirty seconds of each workload, the subject was asked to recite the Pledge of Allegiance, a 31 word paragraph familiar to most people in American culture, and which has been used in previous studies (6,7,8,12).

The exercise intensity during the thirty minute exercise bout was systematically varied in stages of 2 minute duration. Four of the stages were intended to be more intense than the VO_2 at the VT, and seven stages were intended to be at intensities below the VT. One stage was at an intensity equivalent to that at the VT (Figure 1).

An example of the VO_2 response, normalized to the VO_2 at the VT, for a single subject is presented in Figure 2. From the observed VO_2 responses during even minutes from minutes 6-30 (corresponding to the times the subject was required to speak) we predicted whether or not the subject would respond positively (e.g., I can still speak comfortably) or negatively (I cannot speak comfortably) on the basis of the observed VO_2 being below or above the VO_2 at the VT.

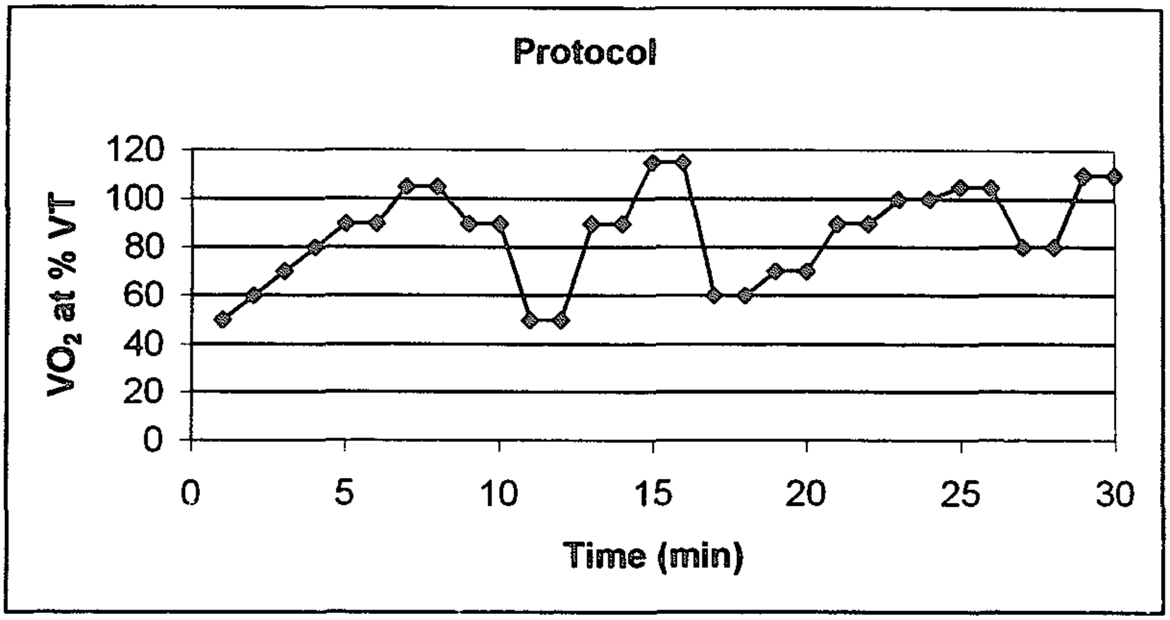

Figure 1. Time vs. VO_2 at percent ventilatory threshold (the protocol used for this study).

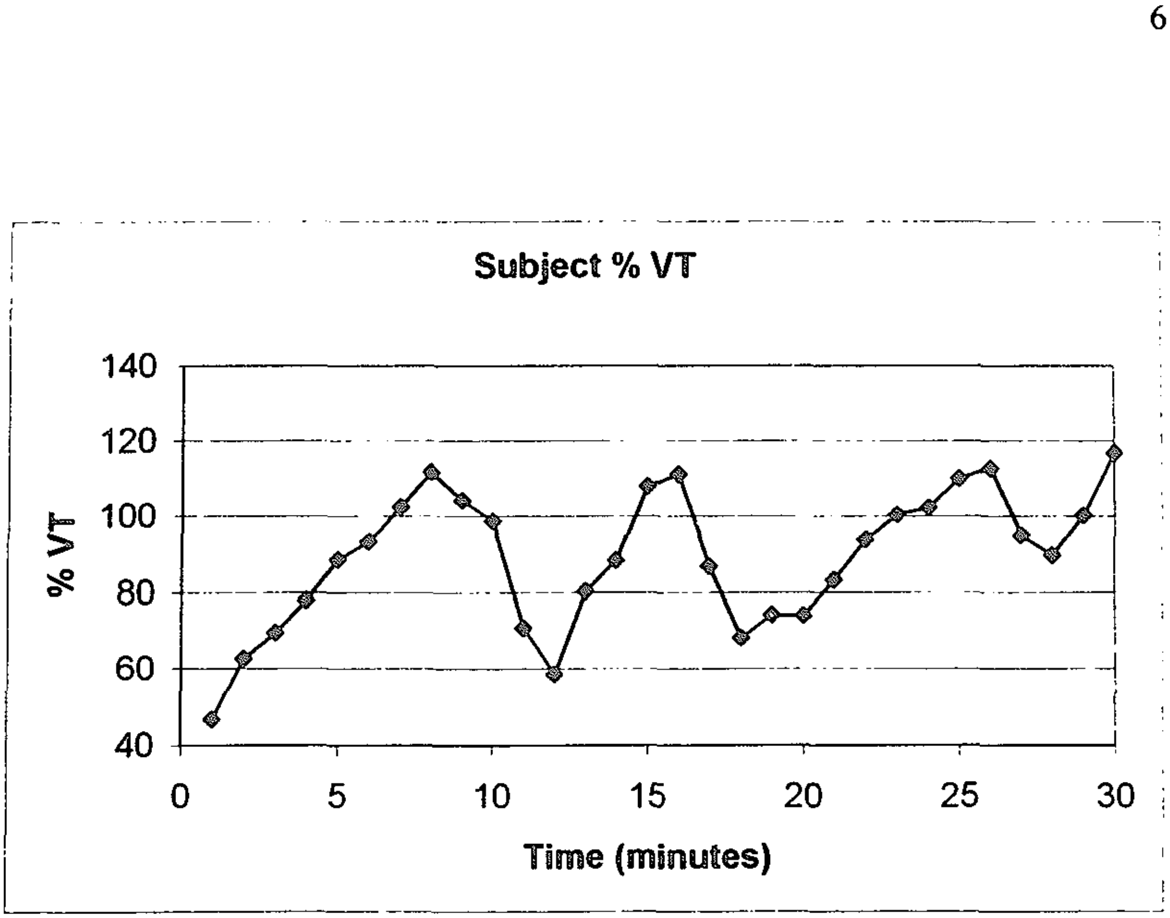

Figure 2. Time vs. percentage of ventilatory threshold for one subject.

An example of the VO_2 response, normalized to the VO_2 at the last positive stage of the incremental TT, for a single subject is presented in Figure 3. From the observed VO_2 responses at even minutes, from minutes 6-30 (corresponding to the times the subject was required to speak) we predicted whether or not the subject would respond positively (e.g., I can still speak comfortably) or negatively (I cannot speak comfortably) on the basis of the observed VO_2 being below or above the VO_2 at the last positive stage.

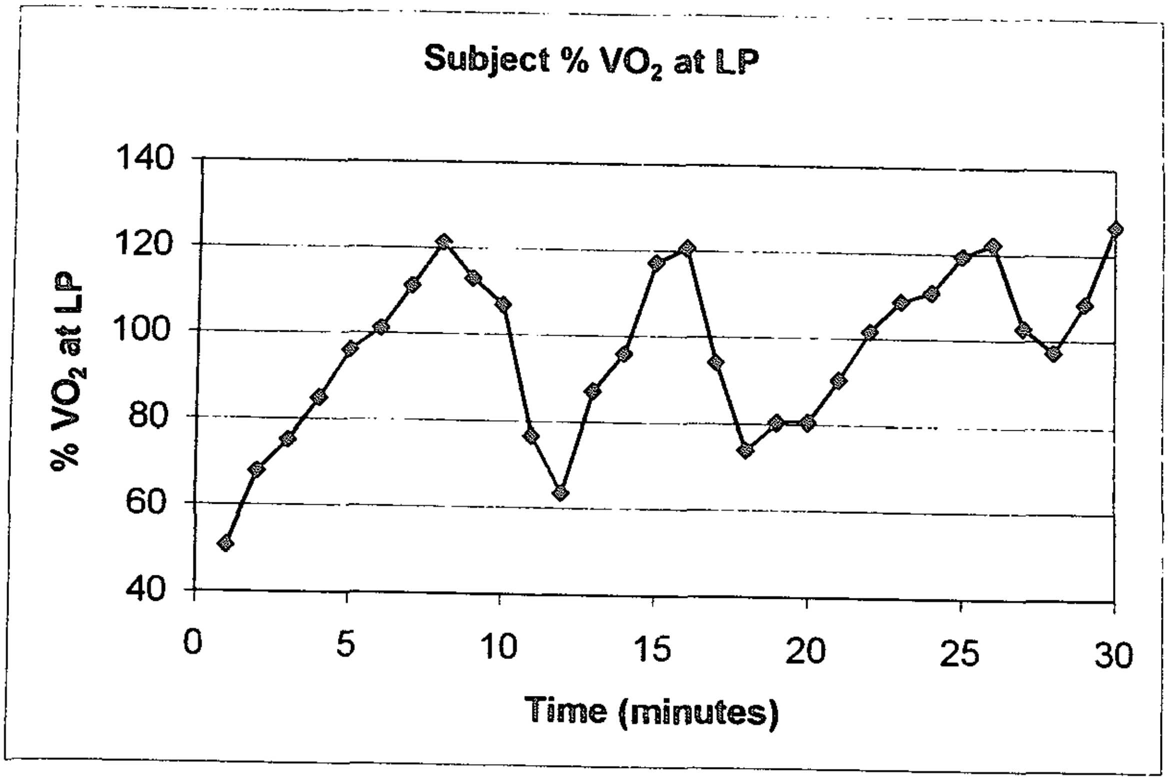

Figure 3. Time vs. percent of VO_2 at the last positive stage of the Talk Test for one subject.

Descriptive characteristics of the subjects are presented in Table 1. The male subjects had a slightly higher VO_2peak ($ml*min^{-1}*kg^{-1}$) than the female subjects. The females were more fit relative to age and gender norms than the males. The mean VO_2 values were comparable with previous studies that examined aerobic capacity (1,2).

Table 1. Descriptive Physical Characteristics of the Subjects

Variable	**Men (n=9)**	**Women (n=9)**
Age (years)	25.3 ± 10.5*	22.4 ± 1.9
Height (cm)	179.7 ± 5.3	167.6 ± 8.2
Weight (kg)	85.3 ± 14.6	62.5 ± 7.7
VO_2peak ($L*min^{-1}$)	3.50 ± 0.56	2.61 ± 0.33
VO_2peak ($ml*min^{-1}*kg^{-1}$)	42.6 ± 9.9	41.8 ± 4.0
% Predicted VO_2	98.3 ± 19.6	108.8 ± 7.3
VO_2 at VT ($L*min^{-1}$)	2.50 ± 0.54	1.99 ± 0.31
% VO_2peak at VT	71.20 ± 8.40	76.40 ± 5.90
HRpeak ($beats*min^{-1}$)	181 ± 22	181 ± 15
HR at VT ($beats*min^{-1}$)	161 ± 26	160 ± 20
% HR peak at VT	87 ± 7	88 ± 5

* Mean ± Standard Deviation

RESULTS

The mean VO_2 response observed during the protocol is presented in Figure 4. As per the protocol, the measured VO_2 exceeded the VO_2 at the VT in four different stages. The VO_2 during the exercise bout also exceeded the VO_2 observed during the last positive stage of the incremental test. The VO_2 during the exercise bout normalized to the VO_2 at the VT is presented in Figure 5. As intended the VO_2 exceeded the VO_2 at the VT at the designed time points. The VO_2 during the exercise bout normalized to the VO_2 at the last positive stage of the TT during the incremental protocol is presented in Figure 6. A comparison of the intended and observed VO_2 responses is presented in Figure 7. In general, there was a close correspondence between the intended and observed responses. During the heaviest workload (15-16 minutes into the protocol) the observed responses were notably less than intended.

The mean heart rate, percent of heart rate max and percent of heart rate reserve responses during the protocol are presented in Figures 8-10. For most of the protocol, the heart rate response was within conventional guidelines for exercise training.

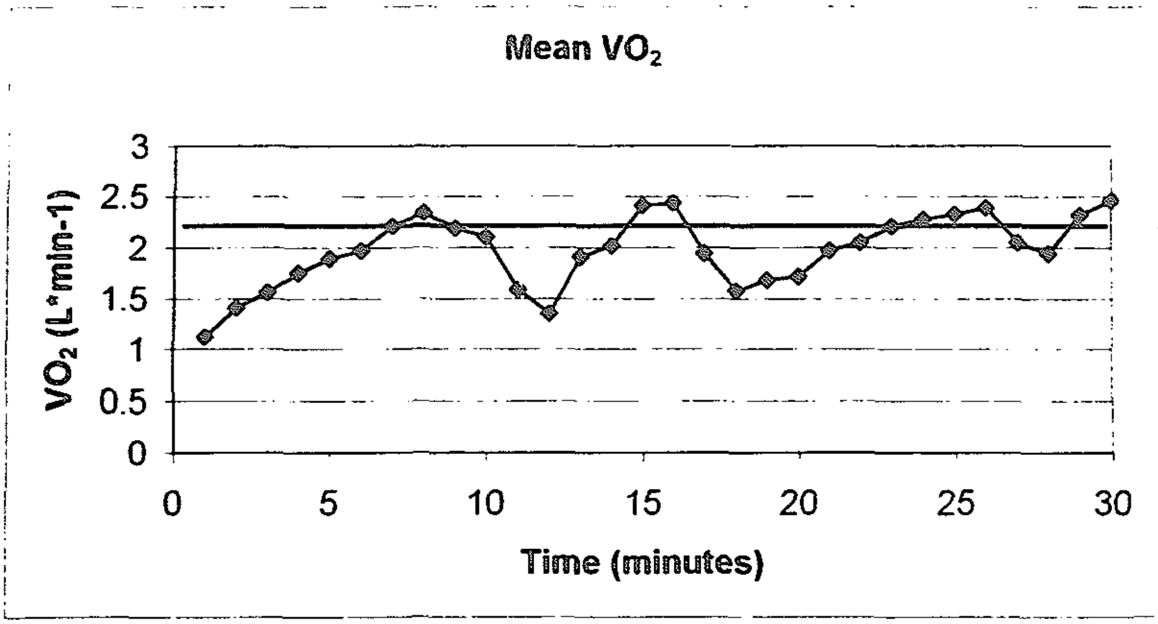

Figure 4. Time vs. VO_2 for all subjects. Bold line represents VO2 at ventilatory threshold and VO2 at the last positive stage of the Talk Test.

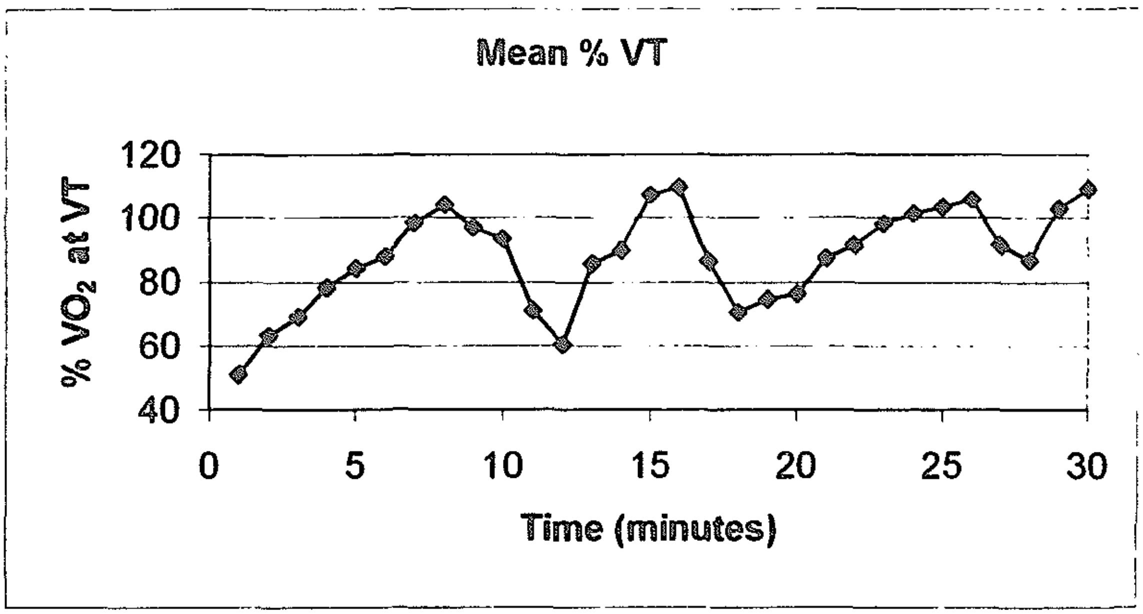

Figure 5. Time vs. percent VO_2 at ventilatory threshold for all subjects.

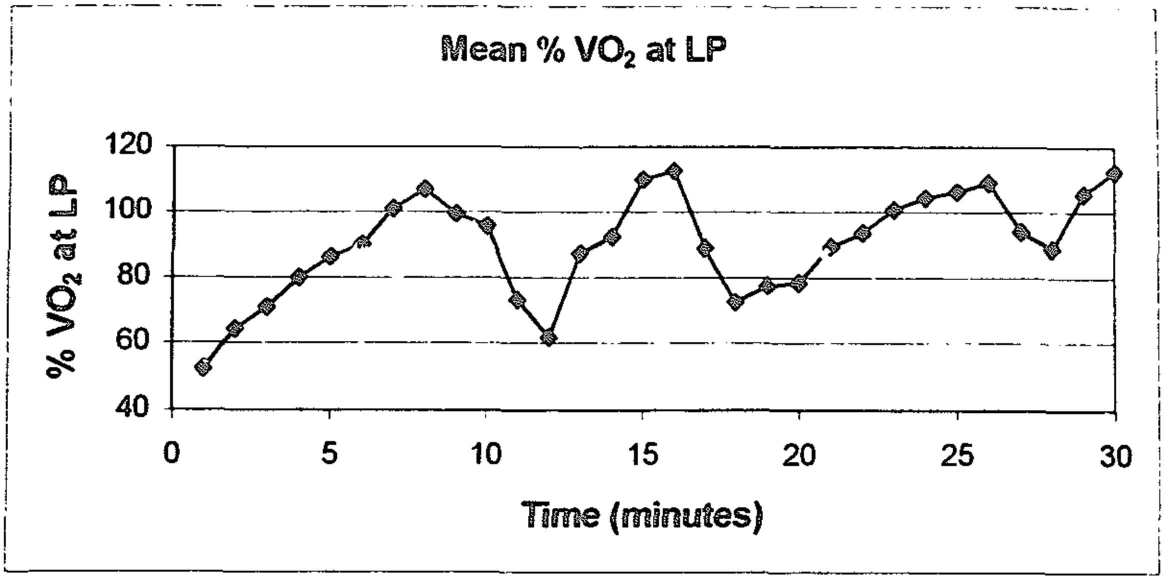

Figure 6. Time vs. percent VO_2 at the last positive stage of the Talk Test for all subjects.

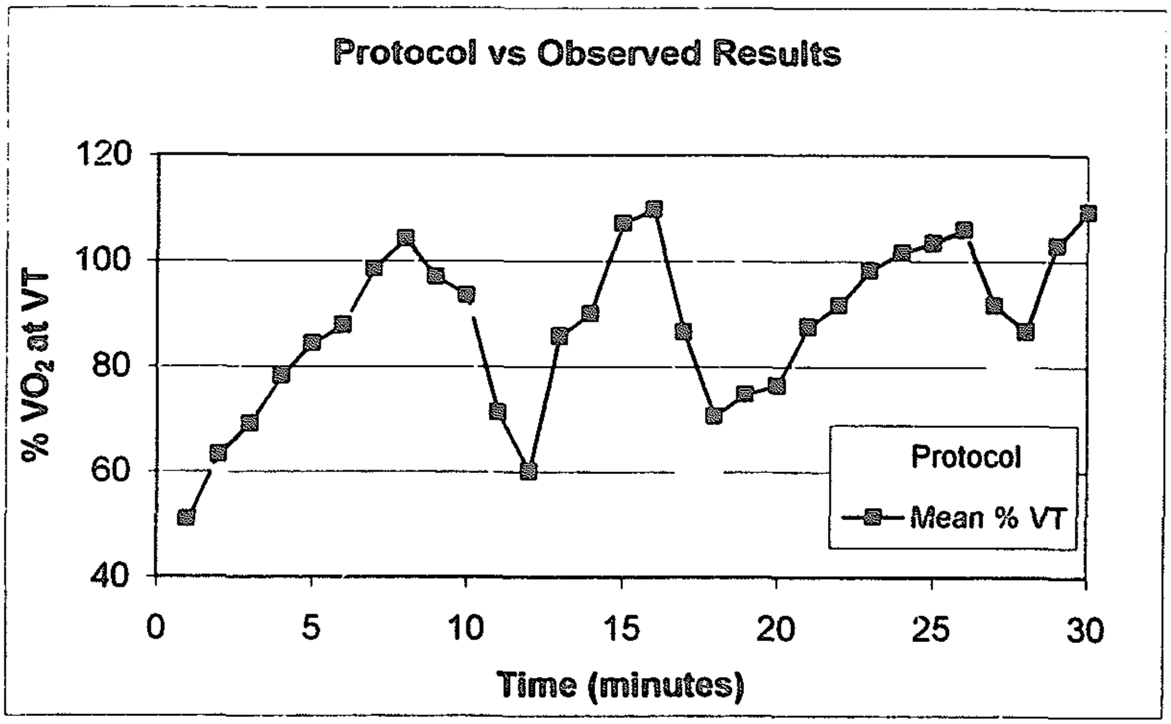

Figure 7. Comparison of time vs. percent VO_2 at ventilatory threshold for the protocol and mean percent ventilatory threshold.

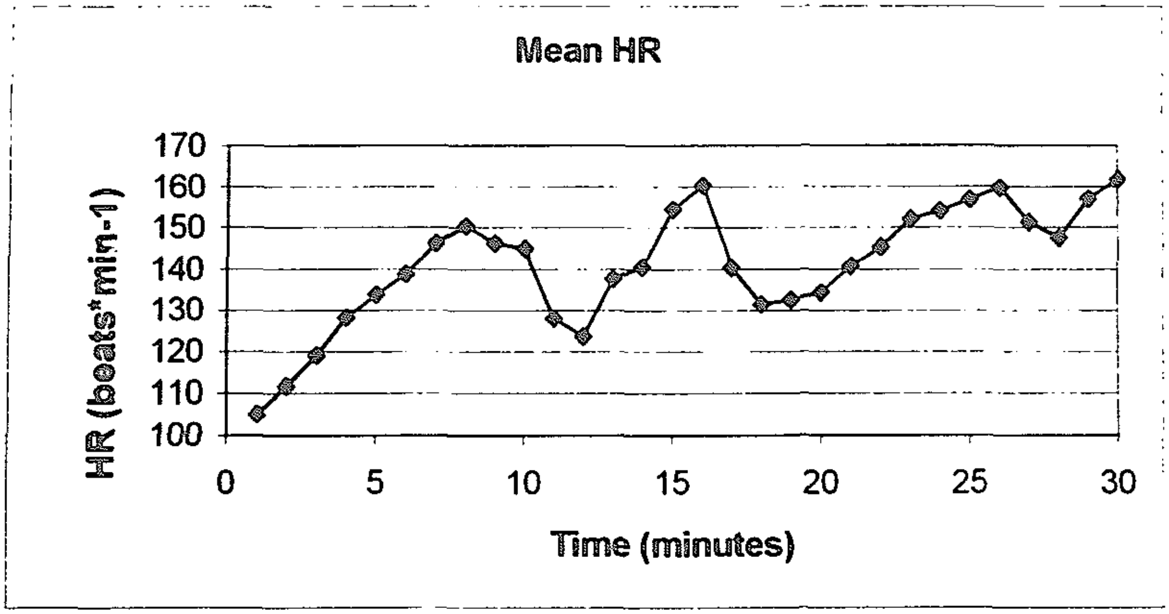

Figure 8. Time vs. heart rate for all subjects.

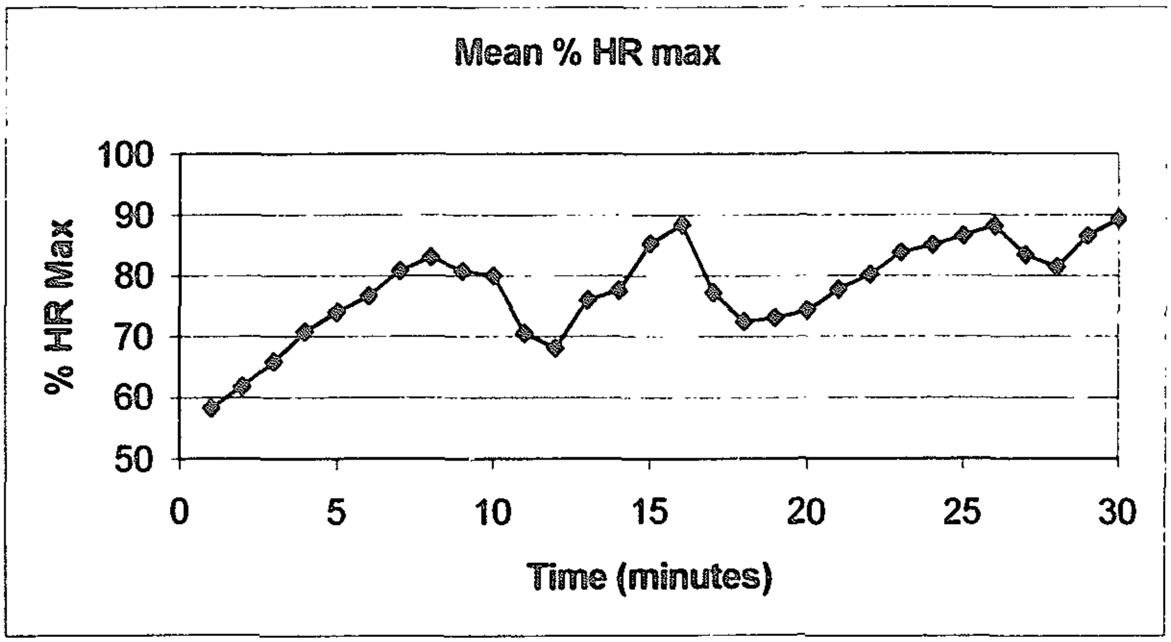

Figure 9. Time vs. percent heart rate max for all subjects.

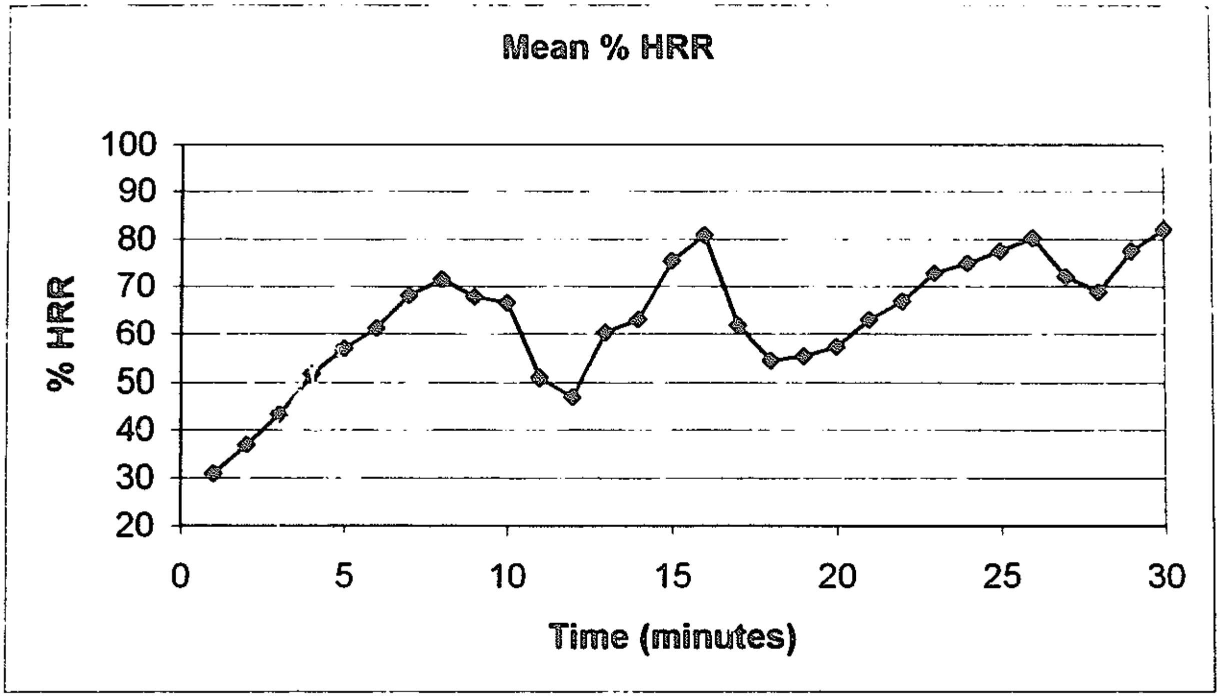

Figure 10. Time vs. percent heart rate reserve for all subjects.

A comparison of the predicted and observed TT responses are presented in Table 2 in relation to prediction based on the observed VO_2 during the protocol, with reference to the VO_2 at the VT. Most (73.1%) of the observed responses were within prediction. Most of the predictive errors (59/63) were in the direction of being able to speak even though the subjects were not predicted to be able to speak (e.g., being able to speak even though the VO_2 exceeded the VO_2 at VT).

Table 2. Expected vs. Observed Response (% VT)

	Expected -	Expected +
Observed +	59	147
Observed -	24	4

% Right = 73.1%
% Wrong = 26.9%

A comparison of the predicted and observed TT responses are presented in Table 3 in relation to prediction based on the observed VO_2 during the protocol, with reference to the VO_2 at the last positive (LP) stage of the talk test. Most (75.2%) of the observed responses were within prediction. Most of the predictive errors (51/58) were in the direction of being able to speak even though the subjects were not predicted to be able to speak (e.g., they could speak even though their VO_2 during the steady state test was momentarily above the VO_2 at LP).

Table 3. Expected vs. Observed Response (% VO_2 at LP)

51	154
22	7

% Right = 75.2%
% Wrong = 24.8%

A comparison of the predicted and observed TT responses are presented in Table 4 in relation to prediction based on the observed VO_2 during the protocol, with reference to the VO_2 at 100%, 105%, 110% and 115% of VT. The results did not fall within the predicted values as well as expected. At 100% and 110% of VT, the predicted values were 27.8% and 33.3% right. Most of the predictive errors (12/13 for 100% of VT) and (11/12 for 110% of VT) were in the direction of being able to speak even though the subjects were not predicted to be able to speak. At 105% and 115%, the predicted values were 52.8% and 55.6% right. The predictive errors (19/19 for 105% of VT) and (8/8 for 115% of VT) were in the direction of being able to speak even though the subjects were not predicted to be able to speak.

A comparison of the predicted and observed TT responses are presented in Table 5 in relation to prediction based on the observed VO_2 during the protocol, with reference to the VO_2 at 100%, 105%, 110% and 115% of the LP stage of the TT. Approximately half of the observed responses were within prediction. At 100% of VO_2 at LP, the predicted values were 50% right. At 105% of VO_2 at LP, 55.6% fell within predicted values. At 110% of VO_2 at LP, the predicted values were 44.4% right. At 115%, 66.7% fell within predicted values. The majority of predictive errors were in the direction of being able to speak even though the subjects were not predicted to be able to speak.

Table 4. Expected vs. Observed Response (% VT) at 100%, 105%, 110% & 115%

100% VT

Observed +

Expected -			Expected +
	12	2	
	3	1	

Observed -

% Right = 27.8%
% Wrong = 72.2%

105% VT

19	9
8	

% Right = 52.8%
% Wrong = 47.2%

110% VT

11	1
5	1

% Right = 33.3%
% Wrong = 66.7%

115% VT

8	1
9	

% Right = 55.6%
% Wrong = 44.4%

Table 5. Expected vs. Observed Response (% VO_2 at LP) at 100%, 105%, 110% & 115%

100% VO_2 at LP

Observed +

Expected -			Expected +
	7	7	
	2	2	

Observed -

% Right = 50%
% Wrong = 50%

105% VO_2 at LP

14	14
6	2

% Right = 55.6%
% Wrong = 44.4%

110% VO_2 at LP

9	3
5	1

% Right = 44.4%
% Wrong = 55.6%

115% VO_2 at LP

5	4
8	1

% Right = 66.7%
% Wrong = 33.3%

A comparison of the predicted and observed TT responses are presented in Table 6 in relation to prediction based on the observed HR during the protocol, with reference to VT. Most (68.8%) of the observed responses fell within predicted values. Most (65/73) of the predictive errors were in the direction of being able to speak even though the subjects were not predicted to be able to speak.

Table 6. Expected vs. Observed Response (HR at VT)

Observed +

Expected -

65	140
21	8

Expected +

Observed -

% Right = 68.8 %
% Wrong = 31.2 %

A comparison of the predicted and observed TT responses are presented in Table 7 in relation to prediction based on the observed HR during the protocol, with reference to the last positive stage of the TT. Most (65.8%) of the observed responses fell within predicted values. Most (74/80) of the predictive errors were in the direction of being able to speak even though the subjects were not predicted to be able to speak.

Table 7. Expected vs. Observed Response (HR at LP)

74	131
23	6

% Right = 65.8%
% Wrong = 34.2%

A comparison of the predicted and observed TT responses are presented in Table 8 in relation to prediction based on the observed breathing frequency during the protocol, with reference to ventilatory threshold. Approximately half of the observed responses fell within predicted values. Most (109/115) of the predictive errors were in the direction of being able to speak even though the subjects were not predicted to be able to speak.

Table 8. Expected vs. Observed Response (B_f at VT)

	Expected -	Expected +
Observed +	109	96
Observed -	23	6

% Right = 50.9%
% Wrong = 49.1%

A comparison of the predicted and observed TT responses are presented in Table 9 in relation to prediction based on the observed breathing frequency during the protocol, with reference to the last positive stage of the Talk Test. The majority (61.1%) of the observed responses did not fall within the predicted values. Most (141/143) of the predictive errors were in the direction of being able to speak even though the subjects were not predicted to be able to speak.

Table 9. Expected vs. Observed Response (B_f at LP)

141	64
27	2

% Right = 38.8%
% Wrong = 61.1%

To summarize the previous tables, table 10 represents all of the data collected during this study. The percent correct includes 1) the expected prediction of being able to speak (expected + on the x-axis) to the observation of being able to speak (observed + on the y-axis) 2) the expected prediction of not being able to speak (expected – on the x-axis) to the observation of not being able to speak (observed – on the y-axis). On the other hand, the percent wrong includes 1) the expected prediction of being able to speak (expected + on the x-axis) to the observation of not being able to speak (observed – on the y-axis) 2) the expected prediction of not being able to speak (expected – on the x-axis) to the observation of being able to speak (observed + on the y-axis).

Table 10. The Percent of Responses Right vs. the Percent of Responses Wrong for the Outcome Variables

Variable	**% Right**	**% Wrong**
% VT	73.1%	26.9%
% VO_2 at LP	75.2%	24.8%
HR at VT	68.8%	31.2%
HR at LP	65.8%	34.2%
Bf at VT	50.9%	49.1%
Bf at LP	38.8%	61.1%
100% VT	27.8%	72.2%
105% VT	52.8%	47.2%
110% VT	33.3%	66.7%
115% VT	55.6%	44.4%
100% VO_2 at LP	50%	50%
105% VO_2 at LP	55.6%	44.4%
110% VO_2 at LP	44.4%	55.6%
115% VO_2 at LP	66.7%	33.3%

DISCUSSION

The purpose of this study was to examine the use of the TT during stochastic exercise. The results were dependent on the variable assessed during the TT (% VT % VO_2 at LP, HR at VT, HR at LP, B_f at VT, B_f at LP). The majority of the observations supported the concept that the VO_2 at VT or HR at VT observed during incremental exercise was a reasonable prediction of whether the subject would be able to talk during stochastic exercise. However, the vast majority of predictive errors were in the direction of the subject being able to speak during stochastic exercise even though during incremental exercise at that level speech was not comfortable.

No current literature has demonstrated the relationship between the TT and stochastic exercise. Therefore, this study cannot be compared to any previous research. In a recent study from our laboratory, Kelso (12) demonstrated that the exercise intensity chosen during a brief steady state exercise bout during which the subjects were instructed to regulate their pace in a way that allowed them to respond comfortably to tape questions was substantially similar to the exercise intensity at the last positive stage of the TT during incremental exercise. These observations, which are somewhat at variance with this studies results, suggest that the TT behaves similarly during incremental and steady state exercise.

Technical limitations of this study exist. First, the protocol chosen used two minute stages. The stages could have been longer, possibly three or four minutes. When using a shorter stage, the subject may not be as fatigued or short of breath while reciting the Pledge of Allegiance. If the stages were longer there may have been more negative responses to the TT. Second, the intensity could have been more difficult. The intensity of the stochastic exercise was set depending on the individuals VT. Results showed individuals could have worked at a higher intensity, possibly 120% or 125% of VT. Another possibility to altering intensity would be to allow the subjects to run instead of walk.

Conclusion

In conclusion, the TT is a good measure of exercise intensity. However, more research must be done to determine a more definitive approach to using the TT during stochastic exercise.

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APPENDIX A

INFORMED CONSENT

INFORMED CONSENT
RELATIONSHIP BETWEEN THE TALK TEST AND VENTILATORY THRESHOLD
DURING STOCHASTIC EXERCISE

I, ________________________(name) consent to participate in a research study conducted at the University of Wisconsin-La Crosse. I have been informed that the purpose of this study is to determine the relationship between a new way of prescribing the intensity of exercise testing, the Talk Test and objective measures of exercise intensity. These objective measures include the pattern of breathing during incremental and alternating hard and easy exercise.

I have been informed that my participation will involve four exercise tests. During all tests, my heart rate will be monitored constantly by wearing a heart rate monitor. During incremental exercise, I will walk on a treadmill while the speed and/or grade of the belt is increased or pedal an exercise cycle until I become fatigued. During alternating exercise, I will walk on the treadmill for thirty minutes while the speed and/or grade is frequently changed (either up or down) or pedal an exercise bike while the workload is changed. I will wear a nose clip and mouthpiece to allow measurement of my expired air.

I have been informed that I will participate in two additional exercise tests using similar protocols, one incremental and one varying. These tests will include the "Talk Test," in which I will read aloud a passage during each two-minute stage of these tests. The Talk Test is used to determine how well I can speak during specific exercise intensities. Heart rate and perceived exertion levels will be monitored throughout each test.

I have been informed that four total hours will be required to complete all of the tests. I have also been informed that I can stop each exercise test at any time or withdraw from the study at any time without penalty.

I have been informed that there are potential risks associated with this study. Risks such as, fatigue, shortness of breath, muscle soreness, abnormalities in heart rate and on rare occasion, heart attack. In patients with known or suspected heart disease, the risk of serious complications during exercise testing is 6/10,000 tests. In prospectively healthy individuals such as myself, the risk of serious complications during exercise testing approximates zero. The test will be terminated if any complications occur. Trained personnel with knowledge in first aid, cardiopulmonary resuscitation and advanced cardiac life support will be on site during the test.

I have been informed that by participating in this study, I will gain knowledge of my own fitness levels and helps exercise professionals to better guide exercise intensity in the general public. Although I have been informed that my individual name and results will be kept confidential, the results of this study may be published.

I have read all the information in this consent and have been informed of the procedures, expectations and risks associated with this study. Any questions that I have will be answered before the signing of this form. If I have further questions I may contact Denise M. Smaczny (796-1390), the primary researcher or Dr. Carl Foster (785-8687), the faculty advisor. Questions regarding the protection of human subjects may be addressed to Dr. Dan Duquette (785-8124), the chair of the University of Wisconsin-La Crosse Institutional Review Board for the Protection of Human Subjects.

Subject: ______________________________________ Date: ____________

Researcher: ___________________________________ Date: ____________

APPENDIX B

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Introduction

When an individual begins an exercise training program she/he must understand the fundamental concepts of an exercise program, which are mode, intensity, frequency, duration and progression. Intensity is the most difficult concept to understand and is frequently forgotten when planning an exercise program.

Even though exercise intensity is difficult to understand, there are many ways to measure it. Some of the more common measurements of exercise intensity are: ventilatory threshold (VT), anaerobic threshold (AT), percent of maximal heart rate (% HR_{max}), percent of maximal oxygen consumption (% VO_2 max), rating of perceived exertion (RPE) and the talk test (TT).

From the list above, the scale of RPE and the TT are subjective methods of measuring intensity. Subjective measuring of intensity is based on an individual's perception and does not require maximal exercise testing. Brawner and Keteyian (1) suggested that 48% of the sample population preferred subjective methods rather than objective methods of measuring exercise intensity.

Currently, the Borg scale (2) is the most common subjective measure of exercise intensity. This is due to a vast amount of research that supports the RPE scale. However, the TT has less documented research, but may offer more advantages than the RPE scale.

Rating of Perceived Exertion

The RPE scale was developed by Borg (2) and is a subjective way to measure exercise intensity. The RPE scale reports how hard an individual perceives they are working while exercising. The original RPE scale ranges from 6-20, but has been modified to 0-10; zero classifying rest and 10 classifying maximal exertion.

There are numerous studies identifying a relationship between RPE and other measures of exercise intensity (3-6). General guidelines for RPE during exercise are ratings of 11-13 on the 6-20 point scale. Dishman and his colleagues (3) reported subjects RPE was between 11-16, which is at or around their target heart rate range (THR). When combining HR and RPE, the subjects were more likely to maintain THR.

Other measures of intensity are related to RPE. When using lactate threshold and blood lactate concentration as criteria, RPE has been shown to be a valid way to prescribe exercise intensity (4). Similarly, Purvis and Cureton (5) report subjects RPE was "somewhat hard" at the anaerobic threshold.

Heart rate is an excellent measure of exercise intensity, but it often requires an inexperienced exerciser to discontinue their workout. Glass and his colleagues (6) found using the RPE scale was advantageous because it did not require an individual to stop and take their heart rate during exercise.

Overall, RPE is an excellent measure of exercise intensity. On the other hand, exercisers must be familiar with the RPE scale to use it properly and avoid underestimating true feelings of exertion.

Talk Test

The TT is a subjective measure of exercise intensity at which an individual can exercise and hold a conversation simultaneously. Previous data suggests the TT is an appropriate measure of exercise intensity during incremental exercise (7-11). On the other hand, no research has been done showing a relationship between the TT and stochastic exercise (exercise of varying intensity).

In 1995, Brawner, Keteyian and Czaplicki (7) conducted a study on sedentary individuals that measured HR and VO_2 max during a maximal exercise test and the TT. In 1997, a similar study measured the same variables, HR and VO_2 max, while combining bicycle testing and the TT (8). Both studies found individuals could still speak comfortably while exercising within American College of Sports Medicine (ACSM) guidelines of 60-90% of VO_2 max.

Dehart-Beverly and her colleagues (9) and Porcari and his colleagues (10) used the TT to measure exercise intensity in college-aged individuals. The results found individuals were comfortable talking below their VT. On the other hand, when subjects were at or beyond VT they were no longer comfortable speaking.

A more recent study by Shafer, et al. (11) found similar results. The subject's ability to speak comfortably disappeared above their VT. Also, a positive response to the TT fell within ACSM guidelines for both % VO_2 max and % HR_{max}.

All of the studies mentioned conveyed a similar message that the TT is an appropriate measure of exercise intensity. Since these studies only measured responses during incremental exercise sessions, more research needs to be done using stochastic exercise.

Ventilatory Threshold

Ventilatory threshold has various definitions and is often interchangeable with anaerobic threshold. VT has been used to estimate AT and has the advantage of being non-invasive. However, the validity of this method is questionable. Anaerobic threshold is defined as the oxygen uptake at which blood lactate begins to rise systematically during graded exercise (12). According to Powers and his colleagues (13) a systematic increase in blood lactate and ventilation do not always occur simultaneously. This suggests limitations in using ventilatory or gas exchange measures to estimate the anaerobic threshold.

The simplified V-slope method can be used to determine VT demonstrated by Schneider, et al. (14) based on a concept developed by Beaver, et al. (15). This method plots carbon dioxide elimination against oxygen uptake during incremental exercise. Next, visual interpolation of the first nonlinear departure with a slope greater then 1.00 occurred and this point is determined to be VT. In the current study, the V-slope method was used to measure exercise intensity.

VO_2 max

A traditional measurement of cardiorespiratory endurance is VO_2 max. Maximal oxygen consumption has been the main objective criteria in evaluating cardiorespiratory fitness (16). VO_2 max can be defined as the maximal amount of oxygen the body can take in, transport and use during exercise.

Although VO_2 max is a great measurement for exercise intensity, the utility of VO_2 max as an estimate of cardiorespiratory endurance has been questioned (16). According to Poole and his colleagues (17) peak cardiac output and muscle oxygen delivery during maximal exercise limits VO_2 max. They conclude that measurements of VO_2 max kinetics gives information about the metabolic potential of the exercising muscles rather than the functioning of the entire cardiovascular, pulmonary and muscular systems. Although VO_2 max was the gold standard, for individuals with cardiovascular disease it may not be the best measurement for exercise intensity.

<u>Steady state versus non-steady state (stochastic exercise)</u>

Previous data regarding the TT involved incremental exercise sessions. However, real world exercise sessions are more stochastic in nature. More research must be done to show the relationship between the TT and stochastic exercise.

During incremental exercise, heart rate gradually increases until peak heart rate is achieved. According to Palmer and his colleagues (18) physiological responses between stochastic and steady state exercise were similar. This study can be helpful when applying the TT to stochastic exercise.

A series of studies were conducted to examine the relationship between stochastic exercise and cardiovascular patients (19,20,21). In 1990, a study was done on post coronary artery bypass graft (CABG) patients assessing the effects of interval training. The results found after CABG surgery, interval training is better suited to increase physical performance and is more effective in utilizing cardiac function (19). Interval training has many positive benefits for the cardiovascular population.

Similarly, two studies were done assessing the difference between continuous versus interval training in cardiovascular patients. In 1996, Meyer and colleagues (20) found interval training could help overcome the premature muscle fatigue seen in continuous training and help prepare patients for coping with activities of daily living. In 1997, the same researchers (21) also found interval training resulted in a greater increase of aerobic capacity than continuous exercise training in post CABG patients.

Conclusion

In conclusion, exercise intensity is an important component of exercise prescription. Subjective measures of exercise intensity are preferred and often more reliable. Previous research regarding the TT found positive results, but only focused on incremental exercise. More research must be conducted regarding the relationship between the TT and stochastic exercise.

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