ABSTRACT

DEHART, M. M. Relationship between the Talk Test and ventilatory threshold. MS in Adult Fitness/Cardiac Rehabilitation, December 1999, 42pp. (C. Foster)

The Talk Test is a widely recommended form of prescribing exercise intensity, however very few studies have specifically evaluated its physiological validity. This study evaluated the relationship between the Talk Test and physiologic changes occurring with exercise. We examined healthy volunteers during incremental exercise. Each subject (N = 28) completed two maximal exercise tests. One test used gas analysis to identify ventilatory threshold (VT). The second was identical, except without respiratory measurements. During this test, the subject read a standard paragraph and reported whether or not they passed the Talk Test. Outcomes at VT and the last positive, positive/negative, and negative stages of the Talk Test were compared. There was a significant ($p < .05$) difference between VO_2, % VO_2peak, HR, and % HRpeak at VT and the positive stage of the Talk Test. There was no significant difference between any of the variables at VT and the positive/negative stage. There was a significant difference between all the outcomes at VT and the negative stage of the Talk Test. We conclude that when subjects could either talk comfortably or were equivocal, they were at or below their VT. Subjects clearly failing the Talk Test were consistently beyond their VT. Thus, the Talk Test is a valid subjective measure to guide exercise prescription.

RELATIONSHIP BETWEEN THE TALK TEST

AND VENTILATORY THRESHOLD

A MANUSCRIPT STYLE THESIS PRESENTED

TO

THE GRADUATE FACULTY

UNIVERSITY OF WISCONSIN-LA CROSSE

IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS OF THE

MASTER OF SCIENCE DEGREE

BY

MEHGAN DEHART

DECEMBER 1999

COLLEGE OF HEALTH, PHYSICAL EDUCATION, AND RECREATION

UNIVERSITY OF WISCONSIN-LA CROSSE

THESIS FINAL ORAL DEFENSE FORM

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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.

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ACKNOWLEDGEMENTS

I would first like to thank Justin, the driving force behind all I do. You are my most constant source of encouragement, patience, and love. Thanks to my parents for your unconditional love and support. Without you, I would not be where I am today. I will always be grateful.

My most sincere thank you goes to my thesis committee chairperson, Dr. Carl Foster. Dr. Foster, thank you for only nearly driving me to a nervous breakdown once. You came into my life at the perfect time. I will always remember you as my special gift from God.

To my other committee members, Dr. John Porcari, Dr. Dennis Fater, and Dr. Richard Mikat, thank you all for your support and assistance throughout this project.

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INTRODUCTION

A major objective of Healthy People 2000 (15) is increasing the proportion of people who exercise. As individuals begin fitness programs, they are usually taught the fundamental basics of exercise, such as recommended frequency, duration, and intensity of exercise. The concepts of frequency and duration are easy to understand for most participants. However, intensity is more difficult to assess for a novice exerciser. It can be identified by various techniques including, but not limited to, percentage of maximal oxygen consumption (VO_2max), ventilatory threshold (VT) (also known as anaerobic threshold), heart rate (HR), or rating of perceived exertion (RPE).

Brawner and Keteyian (5) reported that 48% of all subjects surveyed preferred subjective methods to predict their exercise intensity. Currently, many people use Borg's RPE scale (4) which requires exercisers to rate their exertion on a scale from 0-10. The RPE method requires a working knowledge of the scale and is easier if a copy of the scale and associated verbal anchors are present. These criteria aren't always possible for new participants or exercisers away from a formal facility.

Another subjective method of regulating exercise intensity that is frequently recommended is the Talk Test (1, 2, 12). The Talk Test is a subjective measure that asks the participant to exercise at the highest intensity possible that would still allow them to respond comfortably in conversation. It presumably allows individuals to sense what their body is feeling and adjust their intensity accordingly, but does not require preexisting knowledge, technological devices, or a chart. Although widely recommended to the public, few studies have examined the relationship between the Talk Test and objective measures of exercise intensity. In 1995, Brawner, Keteyian, and Czaplicki (6) and again in 1997, Czaplicki, Keteyian, Brawner, and Weingarten (8) found that ACSM's exercise intensity guidelines of 60-90% of VO_2max were generally met by the Talk Test. However, the question stills remains; how does the Talk Test relate to other measures of intensity? At a common sense level, the Talk Test should be related to VT since high levels of ventilatory control are necessary for reasonably normal speech, and the drive to increase ventilatory frequency (Vf) above the VT (16, 17) would mitigate against high levels of ventilatory control.

Accordingly, the purpose of this study was to determine the relationship between VT and the Talk Test by considering physiological variables associated with VT and three indices of the Talk Test.

METHODS

Subjects

Twenty-eight subjects (14 male, 14 female) from the University of Wisconsin-La Crosse community volunteered to participate in this study. All subjects were regular exercisers and were accepted into the study under the assumption that they were in good health and had no known cardiovascular problems. Prior to participation, all participants completed a Health History Questionnaire (see Appendix A) (3) designed to screen for occult health risks. The study was approved by the Institutional Review Board (IRB) at the University of Wisconsin-La Crosse. Each subject provided written informed consent (see Appendix B) prior to testing. All laboratory testing took place in the University of Wisconsin-La Crosse Human Performance Laboratory.

Experimental Design

Each subject performed two maximal exercise tests which were completed in random order and separated by no more than 2 weeks. Balke or Åstrand type treadmill exercise protocols with 2-minute stages (see Appendix C) were used for each test depending on the subject's exercise habits. If the subject was a walker, they were tested using a Balke type protocol (velocity = 1.56 $m*s^{-1}$). If they were a regular jogger, an Åstrand type protocol was used (velocity = 2.23 $m*s^{-1}$). If the subject was a runner, an Åstrand type protocol was employed at a higher speed (velocity = 3.13 $m*s^{-1}$). One of the two tests was conducted using continuous measurement of respiratory gas exchange. VT was identified via the V slope method (14). HR was assessed using radiotelemetry and RPE was assessed using the category ratio scale of Borg (see Appendix D) (4) during each 2-minute stage. The other test was conducted in an identical manner, but without gas analysis. This test identified when the participants could no longer comfortably (by their own estimation) speak the words of a standard paragraph (Talk Test). During the last minute of each stage of the test, the subjects read "the Rainbow Passage" (e.g. a widely used standard passage in clinical speech pathology) (see Appendix E) (10). They then reported whether or not they felt they passed the Talk Test and indicated their RPE. HR was also recorded at this time.

Instrumentation

During each of the tests, the subjects ambulated on a motorized treadmill (Quinton Instrument Company, Seattle, WA) to volitional fatigue. Each subject was given a 4-minute warm-up at either 3.5 (1.56 $m*s^{-1}$) or 5.0 mph (2.23 $m*s^{-1}$) and 0% grade. During each subsequent 2-minute stage of the Balke or Åstrand protocols, the exercise intensity was increased, by raising the grade by 3.0% and 2.0% for the Balke and Åstrand protocols, respectively, until the subjects could no longer continue.

Immediately preceding the VO_2max test with gas analysis, the Q-Plex Metabolic Analyzer (Quinton Corporation, Bothell, WA) was calibrated using a 2.8 L syringe and known gas concentrations. A Polar Vantage Heart Rate Monitor (Polar CIC Inc., Port Washington, NY) was used to monitor HR continually during both tests.

Statistical Analysis

Differences between the physiologic responses at the VT and three indicators of the Talk Test were compared using paired t-tests with a Bonferoni correction for multiple comparisons. The three indicators of the Talk Test were the last point at which the Talk Test was positive (last +), the point where passing the Talk Test was equivocal (+/-), and the point at which the Talk Test was clearly not passed (-). The level of significance was set at $p < .05$.

RESULTS

The descriptive statistics of the subjects are presented in Table 1. The data are consistent with a young and well-conditioned population. The men were slightly more fit than the women, but both groups were more highly fit than average for age/gender (7.9). The % VO_2peak at VT and % HRpeak at VT was consistent for all groups.

Table 1. Descriptive physical characteristics of the subjects.

Variable	Men (n = 14)	Women (n = 14)	Total (n = 28)
Age (yrs)	23.4 ± 4.5	24.8 ± 7.4	24.1 ± 6.1
Height (cm)	178.3 ± 4.4	167.1 ± 5.2	172.7 ± 7.4
Weight (kg)	76.2 ± 9.0	67.0 ± 9.4	71.6 ± 10.2
VO_2peak ($ml*kg^{-1}*min^{-1}$)	52.6 ± 3.8	40.4 ± 8.1	46.5 ± 8.8
% Predicted VO_2peak	111.9 ± 7.2	104.6 ± 18.2	108.2 ± 14.1
VO_2 at VT ($ml*kg^{-1}*min^{-1}$)	42.7 ± 3.3	32.4 ± 8.0	37.5 ± 8.0
% VO_2peak at VT	80.3 ± 6.9	79.5 ± 7.0	79.9 ± 6.8
HRpeak ($b*min^{-1}$)	192.3 ± 7.6	184.9 ± 14.5	188.6 ± 12.0
HR at VT ($b*min^{-1}$)	173.4 ± 9.5	165.4 ± 18.5	169.4 ± 15.0
% HRpeak at VT	90.2 ± 4.2	89.3 ± 5.6	89.8 ± 4.9

* Mean ± Standard Deviation

The mean values (± standard deviation) for the outcome variables are listed in Table 2. Oxygen consumption, % VO_2peak, HR, and % HRpeak at VT were significantly different at the last positive stage of the Talk Test. There were no significant differences for VE, % VEpeak, Vf, % Vfpeak, RPE, and time at the same stage. Figures 1 - 6 show the individual variables at VT and at the three indicators of the Talk Test.

There were no significant differences between any of the variables at VT and the positive/negative stage of the Talk Test. There were significant positive correlations between VO_2, HR, VE, Vf, RPE, and time at VT and the same variables at the positive/negative stage ($r = 0.91$, $r = 0.84$, $r = 0.88$, $r = 0.90$, $r = 0.63$, and $r = 0.51$, respectively).

There were no significant differences between any of the variables at VT and the negative stage of the Talk Test.

Table 2. Means and standard deviations of outcome variables at VT, last positive, positive/negative, and negative responses during the Talk Test.

Variable	@ VT	@ Last +	@ +/-	@ -
VO_2 (ml*kg^{-1}*min^{-1})	37.5 ± 8.0	35.4 ± 9.4*	37.1 ± 9.3	40.6 ±9.4*
% VO_2peak (ml*kg^{-1}*min^{-1})	80.3 ± 6.1	75.4 ± 9.5*	79.1 ± 9.9	87.0 ± 8.0*
HR	169.4 ± 15.0	161.1 ± 20.3*	165.7 ± 18.7	174.0 ± 16.4*
% HRpeak	89.8 ± 4.9	85.3 ± 7.6*	87.8 ± 6.7	92.3 ± 5.6*
VE	74.3 ± 22.2	70.1 ± 25.6	73.9 ± 26.4	85.6 ± 29.0*
% VEpeak	67.0 ± 8.8	62.3 ± 10.9	66.0 ± 11.6	76.4 ± 12.2*
Vf	37.4 ± 7.0	36.8 ± 7.4	37.1 ± 7.8	39.6 ± 8.3*
% Vfpeak	80.0 ± 9.6	78.6 ± 8.6	79.2 ± 9.0	84.4 ± 8.34*
RPE	5.6 ± 1.3	5.2 ± 1.6	5.8 ±1.6	7.2 ± 1.7*
Time	10.0 ± 1.7	9.0 ± 2.8	9.9 ± 2.6	11.9 ± 2.5*

* indicates significant difference ($p < 0.0167$) vs @ VT for paired t-tests with a Bonferoni correction.

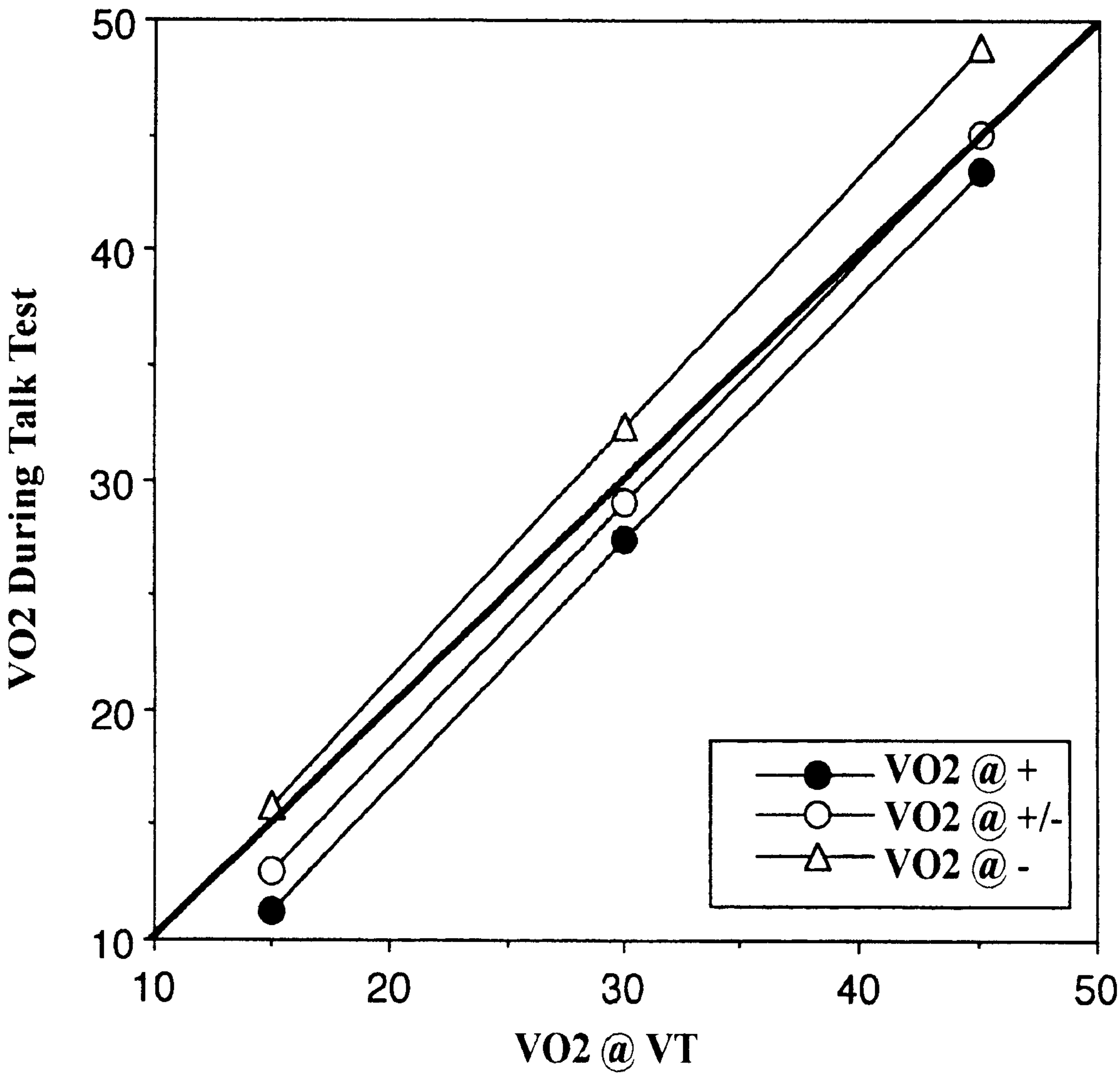

Figure 1. Oxygen consumption at VT versus oxygen consumption at last positive, positive/negative, and negative responses during the Talk Test.

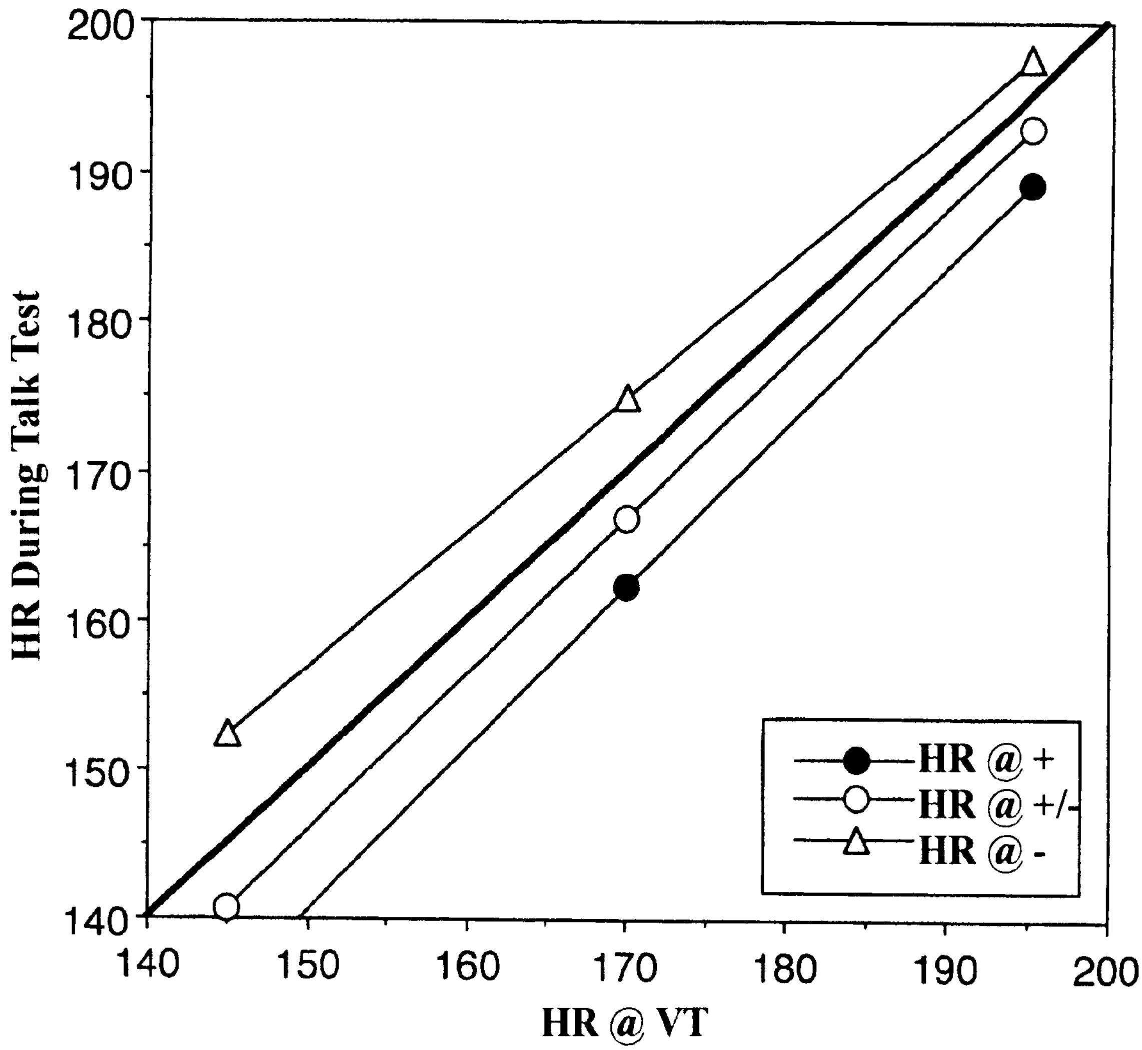

Figure 2. Heart rate at VT versus heart rate at last positive, positive/negative, and negative responses during the Talk Test.

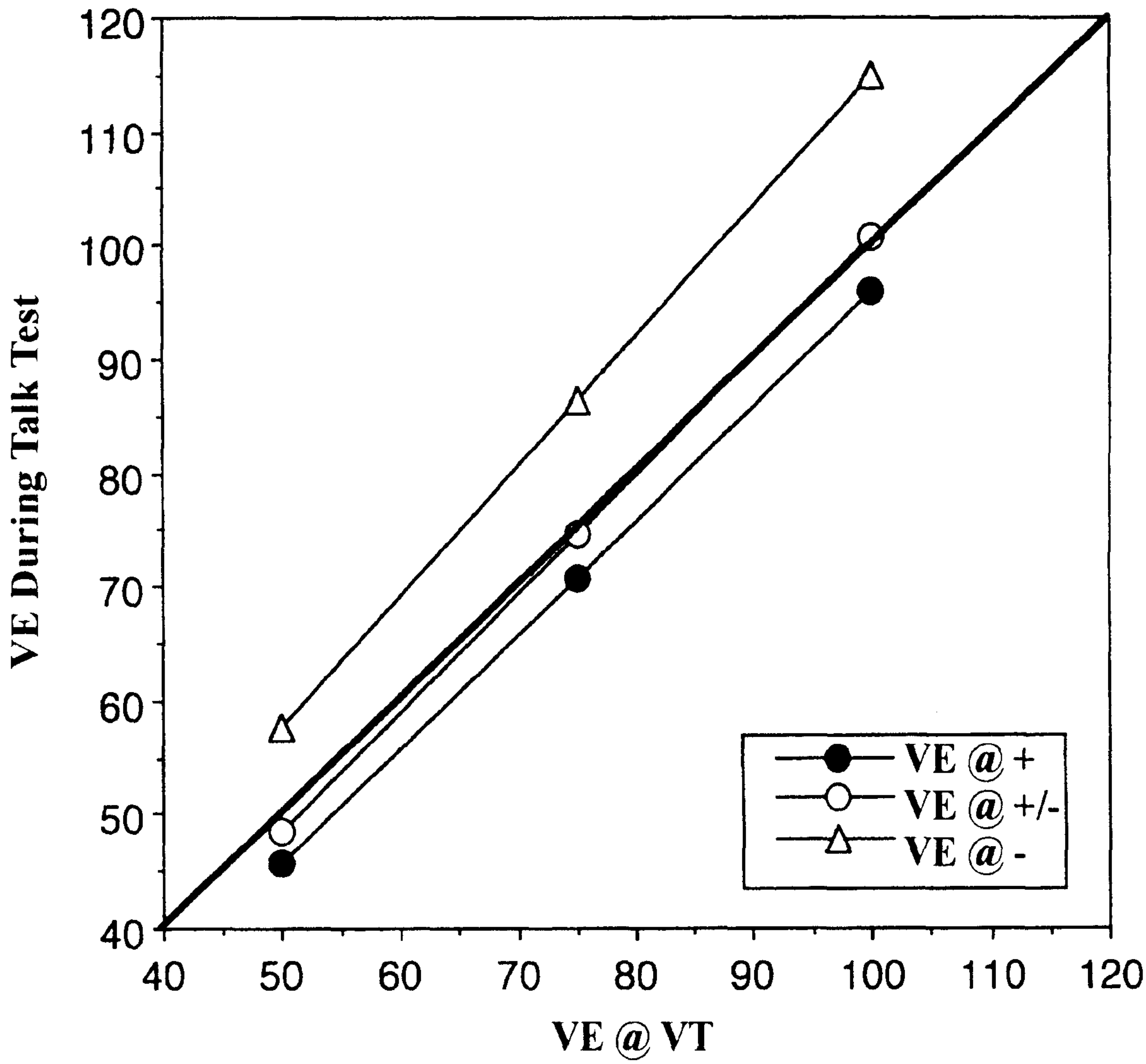

Figure 3. Ventilation at VT versus ventilation at last positive, positive/negative, and negative responses during the Talk Test.

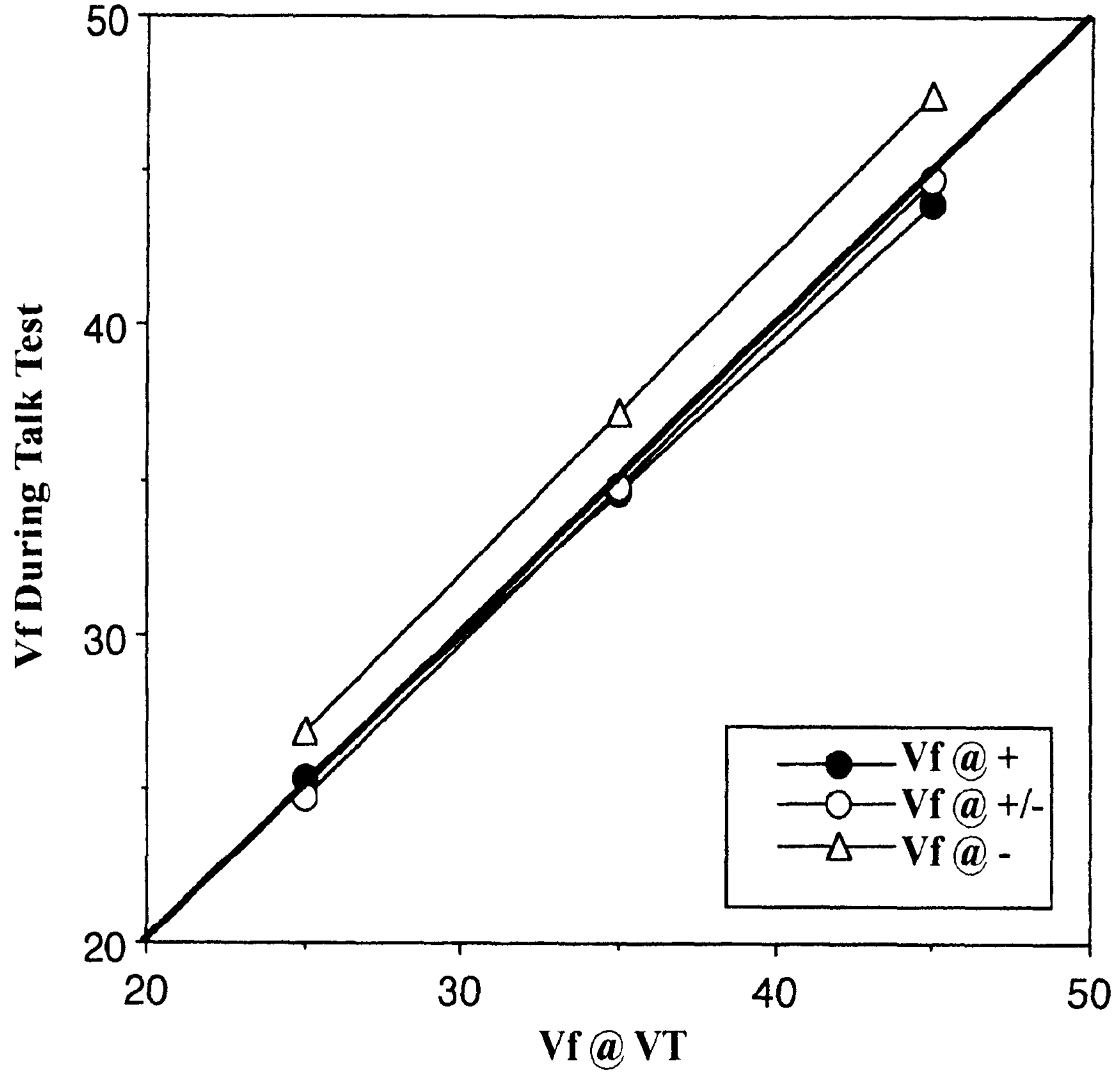

Figure 4. Ventilatory frequency at VT versus ventilatory frequency at last positive, positive/negative, and negative responses during the Talk Test.

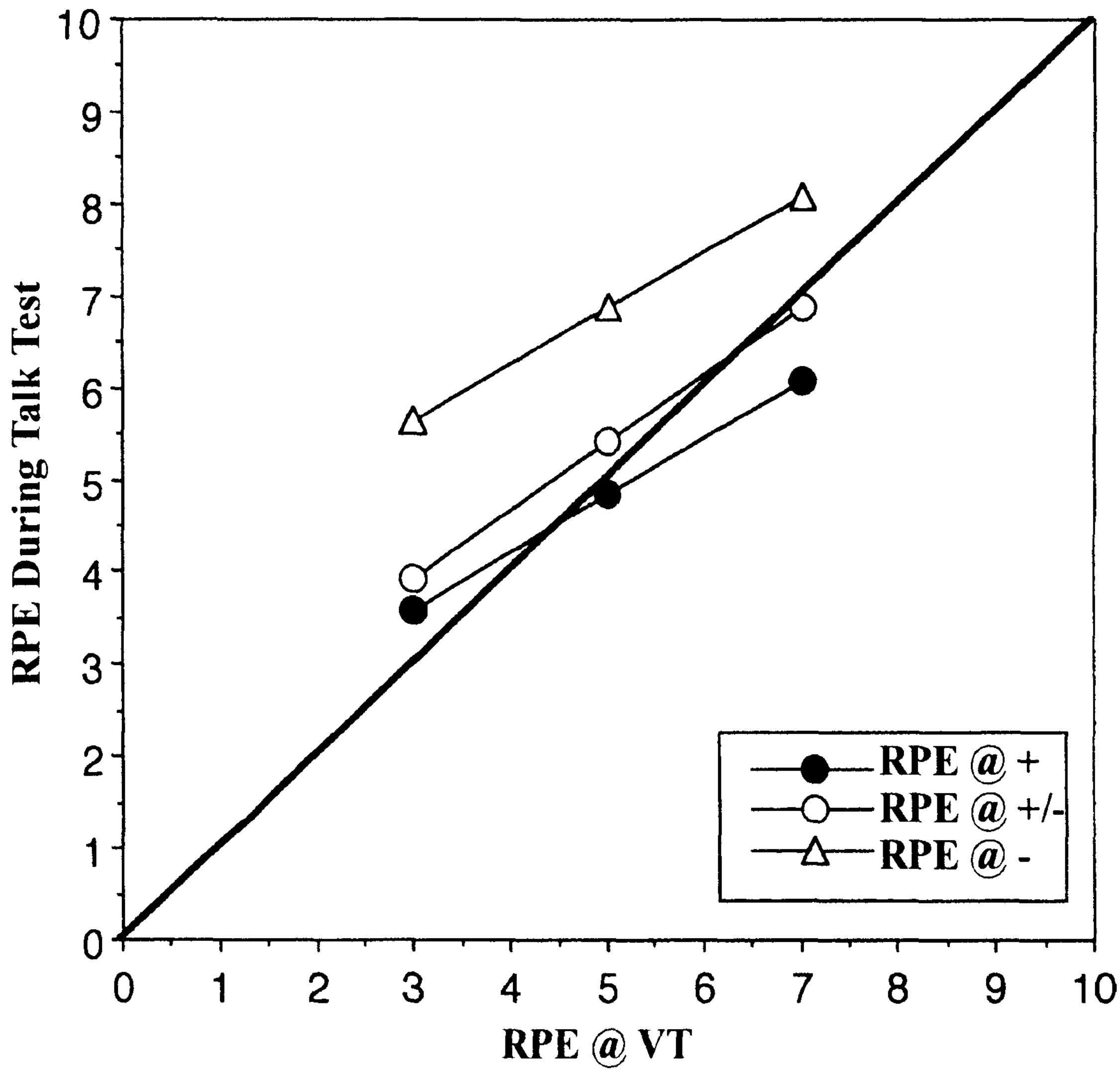

Figure 5. RPE at VT versus RPE at last positive, positive/negative, and negative responses during the Talk Test.

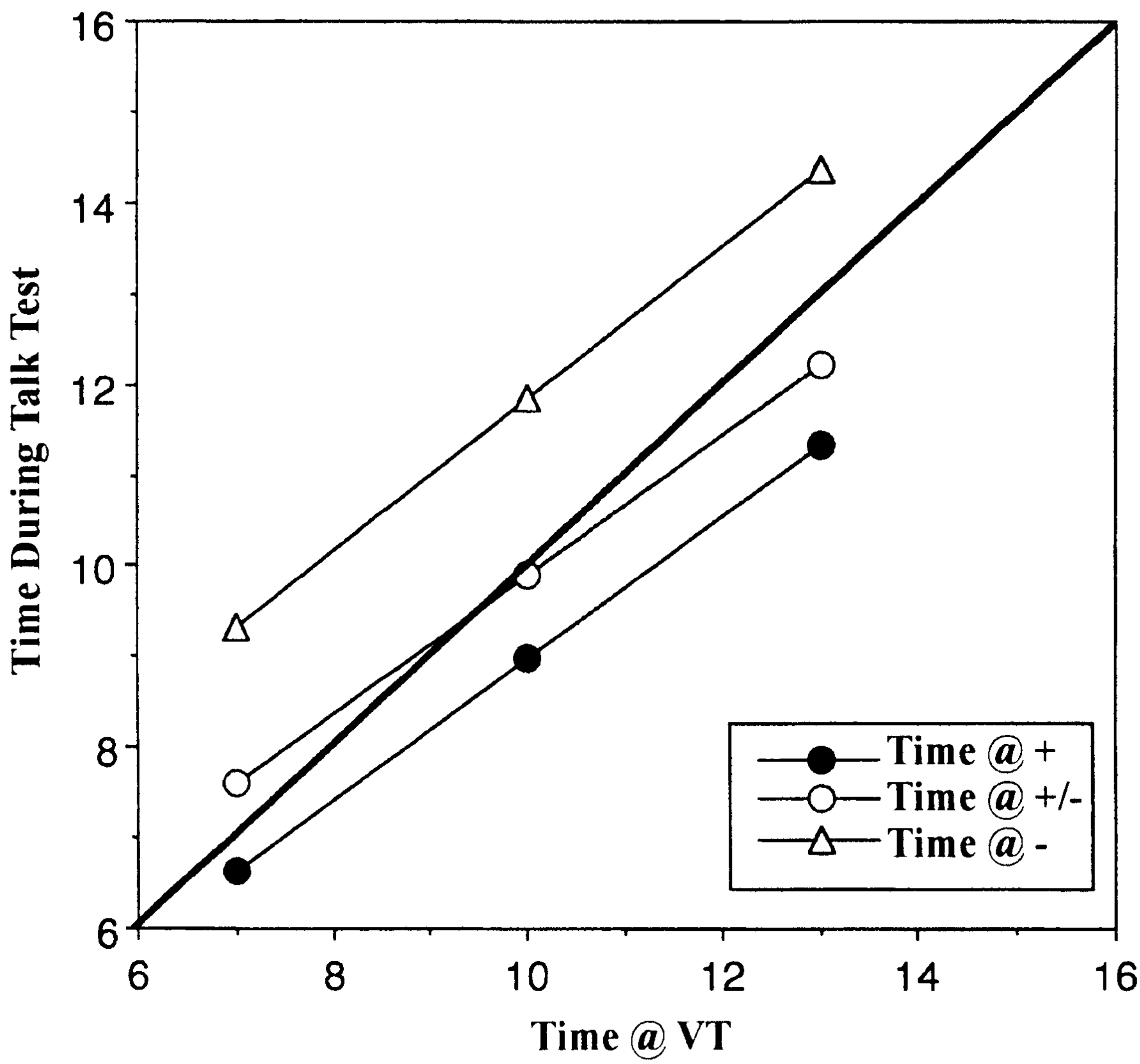

Figure 6. Time at VT versus time at last positive, positive/negative, and negative responses during the Talk Test.

DISCUSSION

The purpose of this study was to determine if the Talk Test relates to physiological changes with exercise, specifically at VT. The results clearly indicate that the point at which an individual is either last passing the Talk Test or beginning to struggle with the ability to talk comfortably is essentially equivalent to their VT. The point where the individual is no longer comfortable talking is consistently associated with values beyond their VT.

Consistent with the ACSM's training recommendations, two previous studies analyzing the Talk Test (6, 8) found the Talk Test to be a good estimate of exercise intensity. This is in agreement with our findings which indicate that the equivocal (i.e. +/-) stage of the Talk Test is essentially equivalent to VT and that failing the Talk Test is beyond VT. ACSM considers VT to be within guidelines for exercise prescription. In addition, we found the last positive or equivocal stage of the Talk Test on average to be at 87.8% of HRpeak. This falls at the upper end of the ACSM's exercise intensity guidelines of 55-90% of HRpeak (13). This suggests that if an individual cannot talk comfortably they are probably beyond the limits of ACSM's exercise recommendations.

There were several possible technical limitations of the study. First, the protocol chosen used 2-minute stages. Ventilatory threshold is best obtained through shorter stages (11). In addition, analysis of Talk Test variable times were limited to 2-minute intervals adversely affecting the temporal resolution of the relationships. Nonetheless, due to technical constraints during the Talk Test, the stage duration could be shortened no further. Second, we utilized a standard 101-word paragraph commonly used in clinical speech pathology to obtain a speech sample (10). This was a long passage, perhaps more extensive than would be commonly spoken during exercise. However, the benefits of the passage are that it is commonly used and forces all subjects to speak a standard amount. The last point is that the subjects included in the study were relatively fit. Their mean predicted % VO_2peak (7,9) was 108.2%. Since the primary application of the Talk Test is to the sedentary public, the study needs to be replicated with sedentary subjects.

Concern that the nature of our Talk Test changed the physiologic variables we were trying to study stimulated analysis of HR and RPE between incremental tests. There were no physiologic differences of practical significance between the gas exchange and Talk Test (see Figures 7 and 8). At matched times, both HR and RPE during the two tests were very similar and show the Talk Test was no more difficult than the gas exchange maximal exercise test.

The findings of this study suggest that when individuals are still able to talk comfortably while exercising they are essentially at or below their VT. When talking while exercising is no longer comfortable, individuals are beyond their VT and are beyond an appropriate training range. Using the Talk Test may be an acceptable method to prescribe and guide exercise intensity.

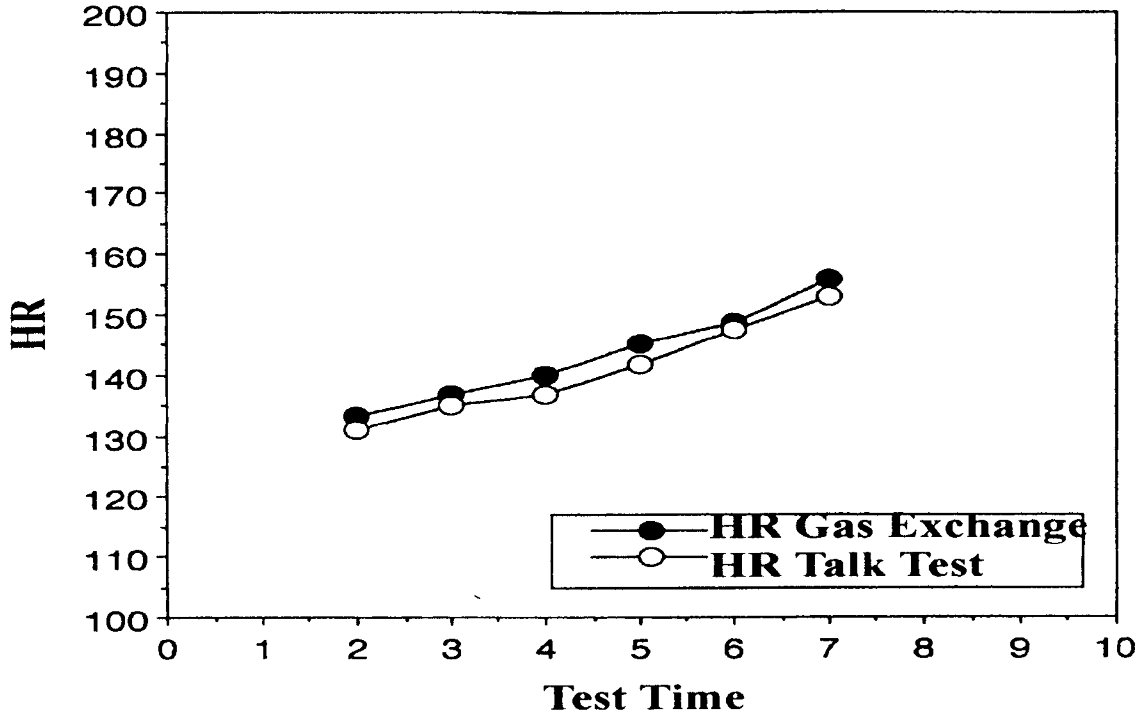

Figure 7. Gas exchange versus Talk Test heart rate responses during the Talk Test.

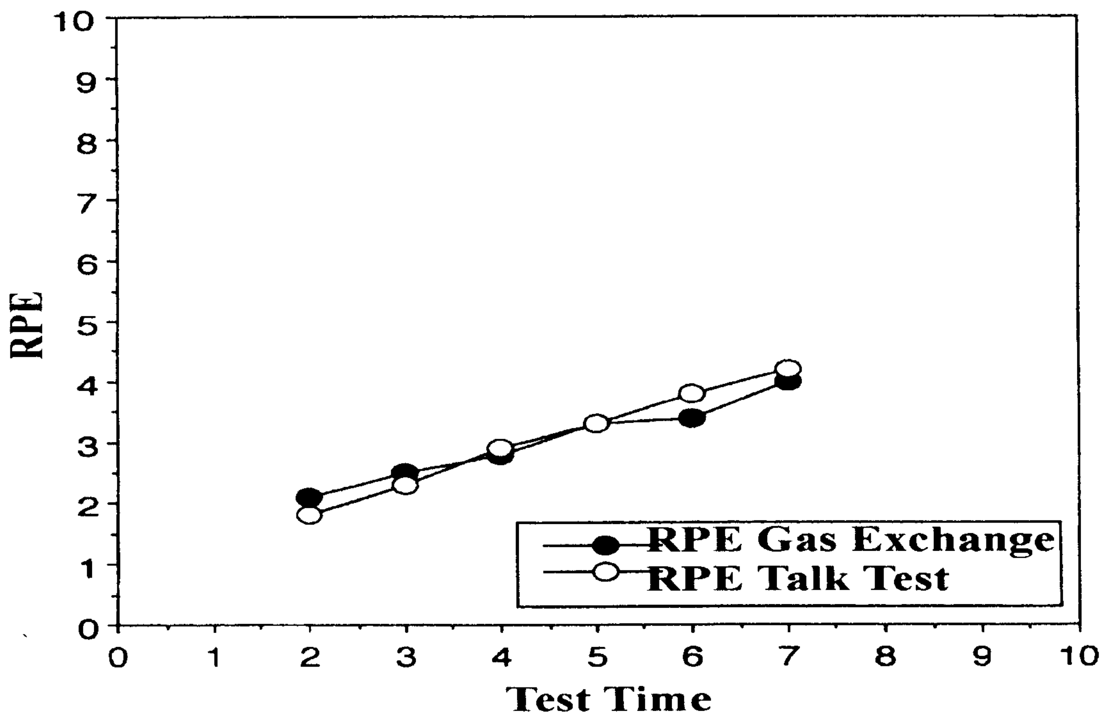

Figure 8. Gas exchange versus Talk Test RPE responses during the Talk Test.

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APPENDIX A

HEALTH HISTORY QUESTIONNAIRE

AHA Health Clubs Risk Factor Screening Tool (3)

If the table suggests seeing one's physician prior to engaging in exercise, stress testing is probably justified on the basis of either evaluating suspicious symptoms or testing for the presence of occult disease.

American Heart Association
Health/Fitness Facility Pre Participation Screening

Assess your health needs by marking all TRUE statements.

History

You have had:

- a heart attack
- heart surgery
- cardiac catheterization
- coronary angioplasty (PTCA)
- pacemaker/ICD/rhythm disturbance
- heart valve disease
- heart failure
- heart transplation
- congenital heart disease

If you have marked any of the statements at the left, you should consult your health care provider before engaging in exercise. You may need to use a facility with a medically qualified staff.

Symptoms

You experience:

- chest discomfort with exertion
- unreasonable breathlessness
- dizziness, fainting, blackouts
- you take heart medications

CV Risk Factors

- you are male over 45
- you are a postmenopausal female not on estrogen therapy
- you smoke
- your blood pressure is > 140/90
- you don't know your blood pressure
- your cholesterol is > 200
- you don't know your cholesterol
- you have a blood relative who has heart problems
- you are diabetic
- you are physically inactive
- you are more than 20 pounds overweight

If you check two or more of the following you should consult your heart care provider before engaging In exercise. You should probably use a facility with a professionally qualified exercise staff.

Other health issues

- you have musculo-skeletal problems
- you have concerns about the safety of exercise
- you take prescription medication
- you are pregnant

- none of the above is true

You should be able to exercise safely without needing to consult with your health care provider, in almost any facility that meets your exercise program needs.

APPENDIX B

INFORMED CONSENT

Informed Consent
Relationship Between the Talk Test and Ventilatory Threshold

I, ____________________ (name), volunteer, to participate in a research study at the University of Wisconsin- La Crosse. I have been informed that the purpose of this study is to determine the relationship between the Talk Test and other physiological parameters (i.e., ventilatory threshold, percentage of maximal oxygen consumption, heart rate, and rating of perceived exertion) at relative workloads and heart rates.

My participation will involve a maximal aerobic power test (VO_2max test) determined by walking or running on a treadmill to voluntary fatigue. I will wear a heart rate monitor strapped to my chest to continuously monitor my heart rate. In addition, I will breathe room air through a mouthpiece so my expired air can be collected and analyzed. During this VO_2max test, I will have a four-minute warm-up at a moderate intensity. Following the warm-up, there will be two-minute stages that will maintain a constant speed, but increase in grade. During the test, my heart rate and RPE will be recorded every minute.

My participation will also involve a second test utilizing the same speed and grade increments. I will again wear a heart rate monitor strapped to my chest to record my heart rate. During this "Talk Test", I will first warm-up at a moderate level for four minutes. During every two-minute stage, I will read a standard 100 word paragraph to evaluate how well I am able to speak at increasing workloads. Heart rate and rating of perceived exertion (RPE) will be recorded near the end of each minute. I realize the approximate amount of time I will be devoting is one hour for each test. I also realize that I can stop either test at any time without penalty.

I have been informed that there are potential risks to my participation in this study, including abnormalities in heart rate, muscle soreness, shortness of breath, general fatigue, and on rare occasions, serious complications such as heart attack. I have also been informed that the risk of serious complications is about 1/10,000 in patients with suspected heart disease. The risk of serious complications in healthy individuals is significantly less than this. Either test will be terminated immediately if abnormal situations occur. Trained personnel with knowledge of the equipment, first aid, and CPR will supervise all activities.

The results of the study may be published. However, I have been informed that my name or identity will remain confidential. Mehgan Dehart will maintain my confidentiality by keeping the data in a personal file and only allowing access to the investigator's research committee.

I consider myself in good health, without infection, or physically limiting conditions, especially regarding my heart, which would preclude my participation in this study.

The only benefit I expect from participating in this study is a better understanding of my own fitness and how I respond to exercise. I have also been informed that the results of this study may help exercise professionals better guide the public regarding appropriate ways to monitor exercise intensity.

I have read the listed information and have been informed of the procedures, expectations, and risks associated with participating in this study. Any questions that I have had have been answered to my satisfaction. I have also been informed that I can withdraw my consent and stop participation at any time without penalty or loss of benefits to my self. If I have further questions I have been informed that I can contact the principal investigator (Mehgan Dehart, 782-0773) or the faculty advisor (Dr. Carl Foster, 785-8687). Questions regarding the protection of Human Subjects may be directed to Dr. Garth Tymeson (785-8155), Chair of UWL – Institutional Review Board for the Protection of Human Subjects.

Signed:____________________________________ Date:__________________

Witnessed:__________________________________ Date:__________________

APPENDIX C

TREADMILL PROTOCOLS

Treadmill Protocols

Balke Protocol

Stage (2 min)	Speed ($m*s^{-1}$)	Grade
I	1.56	0.0%
II	1.56	3.0%
III	1.56	6.0%
IV	1.56	9.0%
V	1.56	12.0%
VI	1.56	15.0%
VII	1.56	18.0%
VIII	1.56	21.0%

Åstrand Protocol

Stage (2 min)	Speed ($m*s^{-1}$)	Grade
I	2.23	0.0%
II	2.23	2.0%
III	2.23	4.0%
IV	2.23	6.0%
V	2.23	8.0%
VI	2.23	10.0%
VII	2.23	12.0%
VIII	2.23	14.0%

APPENDIX D

RATING OF PERCEIVED EXERTION

Borg's Rating of Perceived Exertion Scale (4)

0 Rest

1

2 Easy

3 Moderate

4 Sort of Hard

5 Hard

6

7 Very Hard

8

9

10 Maximum

APPENDIX E

THE RAINBOW PASSAGE

"The Rainbow Passage"

"When the sunlight strikes raindrops in the air, they act like a prism and form a rainbow. The rainbow is a division of white light into many beautiful colors. These take the shape of a long round arch, with its path high above and its two ends apparently beyond the horizon. There is, according to legend, a boiling pot of gold at one end. People look, but no one ever finds it. When a man looks for something beyond his reach, his friends say he is looking for the pot of gold at the end of the rainbow (10, p. 127)."

APPENDIX F

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Introduction

The three fundamental components of exercise training are frequency, intensity, and duration. Of these components, intensity of exercise is the most difficult to assess, especially for individuals new to a fitness program. Many participants find assessment of intensity to be confusing. As a result, this important concept is frequently misinterpreted or overlooked.

Despite the fact that measurement of intensity is often ignored by new fitness participants, there are actually many ways to measure this exercise training component. Some of the most common assessments of exercise intensity are anaerobic threshold, lactate threshold, ventilatory threshold (VT), percentage of maximal oxygen consumption (% VO_2max), percentage of maximum heart rate (% HRmax), rating of perceived exertion (RPE), and the Talk Test.

Of the above listed intensity assessments, all are objective measures, except for RPE and the Talk Test. The RPE and Talk Test are subjective measures that depend on the individual's perceptions. In a study by Brawner and Keteyian (6), 48% of the total sample surveyed preferred subjective measures, as opposed to objective measures, to evaluate their exercise intensity. This study evaluates the importance of functional subjective measures to evaluate exercise intensity.

The two main subjective measures of intensity are RPE and the Talk Test. Currently, the RPE scale is the most commonly used. However, much of this may be due to the large amount of literature available about RPE as opposed to the very few data regarding Talk Test in the literature, which is widely recommended but little studied (1, 2, 14). Regardless, of the relative amount of literature, the Talk Test may offer advantages over the more common RPE scale.

Talk Test

The Talk Test is a subjective measure of exercise intensity in which an individual exercises at the fastest pace possible that still allows them to respond comfortably to conversation. Although many professionals in the exercise and fitness fields know of the Talk Test and recommend it as a concept (1, 2, 14) there has been very little written about it. The Talk Test is assumed to correlate to the VT, but no relationship has been documented.

In 1995, Brawner, Keteyian, and Czaplicki (7) completed a study in which sedentary individuals' heart rate and oxygen consumption (VO_2) were evaluated while performing a graded exercise test and while exercising using the Talk Test. It was found that the Talk Test generally estimates an intensity which falls between the American College of Sports Medicine's (ACSM) 60-90% of VO_2max guidelines. In other samples, the VT also usually falls within this intensity zone.

In addition, Czaplicki, Keteyian, Brawner, and Weingarten (8), conducted an experiment to compare an individual's Talk Test intensity on the treadmill and dual action cycle ergometer. Czaplicki et al. found that when the Talk Test is used to guide exercise intensities on both modalities, workloads are sufficient to obtain ACSM training recommendations in sedentary adults.

Both of these studies suggest that the Talk Test is an effective method to determine exercise intensity. However, to date, these are the only studies available, which specifically address the Talk Test in relation to exercise training. Based on the limited research available, it can be concluded that more research involving the Talk Test is warranted, particularly involving differing populations, the Talk Test's relationship to other intensity measures, and the Talk Test's validity and reliability.

Anaerobic Threshold

Given the numerous studies conducted on the broad topic of anaerobic threshold, there is a wealth of knowledge and information surrounding this measurement of intensity (10). The difficulty in ascertaining the correct information lies in the realization that over the years, multiple terms have developed which describe similar phenomena. In addition, many times the same term describes different things. For example, all of the following terms surround the topic of anaerobic threshold: anaerobic threshold, aerobic threshold, lactate threshold, maximal steady state, individual anaerobic threshold, onset of blood lactate accumulation, and lactate breaking point. Even this incomplete list emphasizes the importance of precisely defining the anaerobic threshold term and occurrence utilized.

Anaerobic threshold generally defined is the exercise level where the aerobic metabolic processes are supplemented by anaerobic processes (22). At this level, as outlined by Wasserman (22), the oxygen requirements by the body tissues are greater than the oxygen being supplied to them. Due to this imbalance, there is an increase in anaerobic oxidation. The lactic acid produced is buffered in the cell and the carbon dioxide (CO_2) produced from the buffering increases the CO_2 output. Additionally, lactate diffuses out of the muscle cell membrane into the blood. Therefore, an increase in blood lactate at a similar time reflects an increase in muscle lactate at an earlier time during exercise (22). In addition, the concentration of lactate in the blood at any time reflects the relative rate of lactate production and clearance (24). For the purposes of this paper, the term anaerobic threshold was used and defined as "the highest VO_2 that can be attained during incremental exercise before an elevation in blood lactate is observed" (24, p. 3).

Multiple identifiers of blood lactate are considered to be accurate and useful tools for determining cardiorespiratory performance and for predicting the ability to maintain a workload. According to Yoshida et al., as reported by Weltman, Snead, Stein, Seip, Schurrer, Rutt, and Weltman (25, p. 31), "lactate threshold was the best predictor of exercise performance." In the study discussed, lactate threshold is synonymous with this study's definition of anaerobic threshold. This idea that anaerobic threshold is a better predictor of cardiorespiratory endurance has been supported by many investigators (11, 20, 23, 25). In addition to cardiorespiratory performance, anaerobic threshold is useful in evaluating a person's ability to maintain a particular workload for an extended period of time (22). This may be due to the fact that anaerobic threshold is closely affected by the supply of oxygen to the tissues, yet is almost independent of effort.

In summary, the large quantities of research literature available coupled with the variety of terms and definitions for anaerobic threshold make it difficult to effectively analyze. However, various investigators have shown that anaerobic threshold is an accurate measure for predicting cardiorespiratory performance and workload maintenance.

Ventilatory Threshold

Similar to anaerobic threshold, there is a wealth of information on ventilatory thershold (VT) and there are various definitions of the term. Ventilatory threshold has, in the past, been used to estimate anaerobic threshold with the advantage of being noninvasive. However, confusion exists about the validity of using ventilatory changes to predict anaerobic threshold. According to Powers, Dodd, and Garner (17), the systematic increase in blood lactate and nonlinear increase in expired ventilation graphed as a function of VO_2 do not always happen at the same point. This suggests a serious limitation in using ventilatory measures to estimate anaerobic threshold. Ventilatory threshold, for this study, was defined as a separate measure from anaerobic threshold and was not assumed to predict anaerobic threshold.

Ventilatory threshold can be determined using the simplified V-slope method as described by Schneider, Phillips, and Stoffolano (19), based on a concept developed by Beaver, Wasserman, and Whipp (3). In this study, carbon dioxide output was plotted against oxygen uptake during incremental exercise. Visual interpolation was then utilized to identify when the first nonlinear departure with a slope greater than 1.00 occurred and this point was determined to be VT. This point was then compared to a computerized method of analyzing VT and a correlation of .95 was found between the two methods. This study illustrates the usefulness of using the simplified V-slope method to identify VT as a measure of exercise intensity.

VO_2max

Cardiorespiratory endurance has traditionally been measured by VO_2max. Maximal oxygen consumption, in the past, has been the main objective criteria for evaluating cardiorespiratory fitness (12, 21). It can be defined as the maximal amount of oxygen the body can take in, transport, and use.

Although there is great value in using VO_2max to evaluate normal versus abnormal cardiovascular functioning (12), the utility of VO_2max as an estimate of cardiorespiratory performance has been questioned, even though many fitness programs still focus on improving VO_2max (24). According to Poole and Richardson (15), VO_2max is limited by peak cardiac output and therefore muscle oxygen delivery during maximal exercise such as running or cycling. They state "in summary, in healthy individuals, measurement of VO_2max kinetics gives information about the metabolic potential of the exercising muscles rather than the integrated functioning of the entire cardiovascular, pulmonary and muscular systems" (p. 317). This information indicates that although historically VO_2max was the gold standard for determining cardiorespiratory performance, currently it's validity and utility are being questioned.

Rating of Perceived Exertion

The rating of perceived exertion scale was developed by Borg (4) and it subjectively asks the individual user to rate their perceived level of exertion throughout their entire body on a 15 point scale from 6-20. It has been modified into a 10 point category ratio scale in response to perceived difficulties with the original version (5). Currently, this method of interpreting exercise intensity is highly recognized and frequently used in health and fitness arenas.

There have been many studies correlating RPE scales to other measures of exercise intensity (4, 9, 13, 18, 20). Purvis and Cureton (18) report an RPE of "somewhat hard" corresponding to anaerobic threshold. Similarly, a study reported by Porcari et al. (16) found that self-selected walking pace yielded an RPE of 11.7. In addition, RPE is linearly related to percentage of VO_2max and there is a strong positive correlation between RPE and HR, VO_2, and ventilation (18). The results of these studies show that RPE is related to other known measures of exercise intensity.

In summary, exercise intensity is an important concept, but it is frequently overlooked or misinterpreted by individuals new to exercise because it is difficult to assess accurately. When given a choice, subjective measures to evaluate exercise intensity are preferred. A limited amount of research has been conducted regarding the

Talk Test, but it may provide more advantages than other methods of measuring exercise intensity.

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