ABSTRACT

SHAFER, N. N. Relationship between the talk test and ventilatory threshold. MS in Adult Fitness/Cardiac Rehabilitation, August 2000, 44pp. (C. Foster)

Previous studies with healthy, physically active individuals have demonstrated that the ventilatory threshold (VT) is closely associated with the highest exercise intensity at which subjects may speak comfortably, the Talk Test (TT). However, public health recommendations regarding the utility of the TT for exercise prescription are usually made for sedentary populations. In this study, the relationship between the VT and TT in healthy, sedentary individuals were evaluated. Subjects (N = 10) performed incremental treadmill exercise with gas exchange to define VT. In random order, they also repeated the exercise test and provided speech samples using either the Rainbow Passage (RP), 101-words, or the Pledge of Allegiance (PA), 31-words. The VO_2 at VT was 18.0 ± 3.2 ml • min^{-1} • kg^{-1}. During the last stage with comfortable speech (positive) the VO_2 was 20.6 ± 1.6 (RP) and 22.2 ± 4.8 (PA) ml • min^{-1} • kg^{-1}. At the equivocal stage (positive/negative) of the TT, the VO_2 was 22.6 ± 1.4 (RP) and 24.8 ± 6.0 (PA) ml • min^{-1} • kg^{-1}. At the negative stage of the TT, the VO_2 was 26.2 ± 1.6 (RP) and 27.3 ± 7.4 (PA) ml • min^{-1} • kg^{-1}. All comparisons were significantly greater than the VO_2 at VT. There were no significant differences between the RP and PA. At VT, the %HRmax was 74 ± 2, at positive 78 ± 3% (RP) and 80 ± 3% (PA), at equivocal 86 ± 3 (RP) and 86 ± 2% (PA), and at negative 93 ± 2 (RP) and 95 ± 2% (PA). The results are somewhat at variance with the previous results, in that VT was passed before the ability to talk comfortably disappeared. However, the positive stage of the TT was still within ACSM guidelines, both for %VO_2max and %HRmax. Further, the results suggest that the relatively simple PA can be used interchangeably with the previous validated RP.

RELATIONSHIP BETWEEN THE TALK TEST AND VENTILATORY THRESHOLD

A MANUSCRIPT STYLE THESIS PRESENTED

TO

THE GRADUATE FACULTY

UNIVERSITY OF WISCONSIN-LA CROSSE

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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:

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The candidate has successfully completed the thesis final oral defense.

Thesis Committee Chairperson Signature — Date: 4/21/00

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

Associate Dean, College of Health, Physical Education, and Recreation — Date: 5-3-00

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TABLE OF CONTENTS

LIST OF TABLES

TABLE PAGE

LIST OF FIGURES

LIST OF APPENDICES

INTRODUCTION

The major goal of the 1996 U. S. Surgeon General's Report on Physical Activity and Health (1) was to increase the number of people exercising in the United States. The benefits of exercise are extensive and range from decreasing premature mortality to fighting chronic diseases to improving the quality of life. To achieve these benefits, one must perform regular, moderate physical activity in addition to maintaining good nutrition habits. However, the United States is increasingly shifting away from a physically active lifestyle, evidenced by reports that 60% of adults are not regularly physically active (1). A number of health agencies have been campaigning and offering advice to the general public to promote healthy lifestyles. It seems the healthy are getting healthier, but the sedentary are becoming more lethargic.

In providing guidance to the public regarding exercise, there are four characteristics of an exercise program that are important. These characteristics include frequency, intensity, duration, and mode. Some are more easily understood, while others leave the general public puzzled. Perhaps the most important, and most confusing of the four is the term intensity. Generically, intensity is the rate of energy expenditure or how hard you are working while exercising.

There are several techniques and methods to help gauge intensity including ventilatory threshold (VT), anaerobic threshold (AT), heart rate (HR), maximal oxygen consumption (VO_2max), Rating of Perceived Exertion (RPE), and the Talk Test (TT).

To establish VO_2max or VT, the subject must complete a maximal exercise test. Heart rate is more easily understood. It is only valuable as a marker of exercise intensity with reference to maximal heart rate (HRmax), which also requires a maximal exercise test. Borg's RPE scale (2) allows the exerciser to rate his/her exertion on a scale from 0-10. Ratings of 3-4 (moderate to somewhat hard) are generally associated with appropriate levels of exercise intensity for exercise. This is a useful method of intensity regulation for the general public if the individual is aware of the scale, although about 10% of exercisers have difficulty using it (3). In many fitness facilities, posters are displayed to promote the use of this method of regulating exercise intensity.

In 1997, Brawner and Keteyian (4) reported that subjective measures, such as the ability to breathe or talk, were preferred when dealing with intensity measures. The TT monitors intensity by asking the participant to exercise while carrying on conversation, but to stop or slow down at the point they are uncomfortable speaking. This method is easily applicable to the general, sedentary population because there is nothing complicated to comprehend, nor are charts needed. The TT is a subjective intensity measure recommended by many professional organizations (5-8). It is paradoxical that exercise related organizations would recommend the use of the TT when there is only a small amount of literature to support its use.

The first study concerning the TT took place in 1995 (9) and was replicated again in 1997 (10). In both investigations, the exercise intensities at which subjects could still speak comfortably ranged within ACSM's recommendation of 60-90% of VO_2max. In 2000, Dehart-Beverley et al. (11) provided supportive data for the use of the TT with

college-aged students. Here again, the results fell within ACSM's exercise intensity guidelines of VO_2max. However, this study was limited in that exercise recommendations, which include the TT, are typically targeted to middle-aged, sedentary individuals, rather than to the somewhat more active and fit college students used by Dehart-Beverley et al. Accordingly, this investigation evaluated the TT in a sedentary population, since this is the target audience for this type of recommendation.

METHODS

Subjects

Ten subjects were screened using a questionnaire (12) developed by the American Heart Association and the ACSM (see Appendix A). All subjects were from the La Crosse, Wisconsin community. The subjects were classified as sedentary, in that they performed regular aerobic exercise two or less times per week with continuous duration being less than 30 minutes. Each participant was in good health, had appropriate responses on the screening instrument, and had no history or symptoms suggestive of cardiovascular disease. Informed consent (Appendix B) was obtained prior to testing and the University of Wisconsin-La Crosse Institutional Review Board had approved the protocol.

Protocol

Each subject performed three randomly ordered exercise tests which were completed within a two-week period. A Modified Balke treadmill protocol (see Appendix C) was used for all tests (13). For female participants, the walking pace was 3.0 mph and for male participants the walking pace was 3.5 mph. The treadmill belt was

initially horizontal, and the grade increased by 2.5%, every 2 min. The subject exercised until fatigue. Each participant warmed-up by walking on the horizontal treadmill at a significantly slower (2.0 mph) speed than the selected pace, for 4 min.

One exercise test was performed with measurement of respiratory gas exchange, using open circuit spirometry. A metabolic cart (Quinton Instruments Company, Bothell, WA) was used to analyze expired air. During this test, VT was identified using the V slope method (14). A radiotelemeter HR monitor was used to continuously monitor HR (Polar Electro Oy, Finland). At the end of every minute, HR was recorded. The RPE, based on Borg's category-ratio scale (see Appendix D), was noted at the same time (2).

The other two tests were conducted using the same protocol, but without respiratory gas analysis. During these tests, the subject was required to recite either a 31 or 101-word paragraph while exercising. At the end of the each stage, the subject read either the "Rainbow Passage" (15), a commonly used instrument in speech pathology, or the "Pledge of Allegiance", a somewhat shorter passage that is well known to virtually everyone in our culture, located in Appendices E and F, respectively. The exercise protocol was otherwise identical. During the last 15-s of each stage, whether or not the participant perceived him/herself to have passed the TT was recorded. Heart rate and RPE were also recorded in 1 min intervals throughout treadmill testing.

Statistical Treatment

Repeated measures analysis of variance (ANOVA) was used to compare the three indices of the TT with the VT. A Tukey comparison was done when ANOVA indicated post hoc comparisons. The level of significance was set at $p < 0.05$.

RESULTS

The descriptive statistics of the subjects are summarized in Table 1. The mean VO_2max of 28.1 ml • min^{-1} • kg^{-1} coincided with, or was lower than, other published studies that examined the relationship between sedentary individuals and aerobic capacities (16,17).

Table 1.

Descriptive Physical Characteristics of the Subjects.

Variable	Subjects (N = 10)
Age (yrs)	38.1 ± 2.3 *
Height (cm)	168 ± 3
Weight (kg)	74.3 ± 4.4
VO_2peak (ml • min^{-1} • kg^{-1})	28.1 ± 1.3
% Predicted VO_2peak	81.5 ± 3.2
VO_2 at VT (ml • min^{-1} • kg^{-1})	18.0 ± 3.2
% VO_2peak at VT	64.9 ± 3.3
HRpeak (beats • min^{-1})	171.6 ± 4.4
HR at VT (beats • min^{-1})	126.5 ± 4.8
% HRpeak at VT	73.8 ± 2.4

* Mean ± Standard Deviation

In random order, each subject performed an exercise test while speaking a standard paragraph, either the Rainbow Passage or the Pledge of Allegiance. The mean values (± SD) for the outcome variables using the Rainbow Passage are listed in Tables 2.

Table 2.

Mean (± SD) of Outcome Variables at VT, Last Positive, Positive/Negative, and Negative Responses During the Rainbow Passage Talk Test.

Variable	@ VT	@ +	@ +/-	@ -
VO_2 (ml • min^{-1} • kg^{-1})	18.0 ± 1.0	20.6 ± 1.6*	22.6 ± 1.4*	26.2 ± 1.6*
% VO_2peak	64.9 ± 3.3	73.3 ± 4.8*	80.6 ± 4.1*	93.2 ± 1.1*
HR (beats • min^{-1})	126.5 ± 4.8	133.6 ± 6.0	148.6 ± 7.4*	159.8 ± 5.1*
% HRpeak	73.8 ± 2.4	77.9 ± 2.9*	86.4 ± 3.3*	93.1 ± 1.9*
V_E (L • min^{-1})	33.2 ± 3.0	39.6 ± 3.6	44.3 ± 3.3*	56.2 ± 3.8*
% $V_E$peak	53.1 ± 3.2	63.2 ± 4.3*	71.2 ± 4.2*	88.3 ± 2.1*
Vf (breaths • min^{-1})	24.1 ± 1.6	26.4 ± 1.8	27.9 ± 1.9*	30.3 ± 1.9*
% Vfpeak	73.6 ± 2.8	80.4 ± 2.5*	84.7 ± 2.1*	92.2 ± 1.2*
RPE	3.1 ± 0.4	4.3 ± 0.6*	5.3 ± 0.6*	6.6 ± 0.7*

* indicates significant difference using a Tukey comparison vs. VT

During the last positive stage of the Rainbow Passage, VO_2, %VO_2peak, %HRpeak, %$V_E$peak, %Vfpeak, and RPE were all significantly different than at VT. There were no significant differences for HR, V_E, and Vf at this stage. All variables:

VO_2, %VO_2peak, HR, % HRpeak, V_E, % $V_E$peak, Vf, %Vfpeak, and RPE, were significantly greater at the positive/negative and negative stages of the Rainbow Passage TT in comparison to the VT.

Table 3 presents the mean (± SD) responses of the Pledge of Allegiance test. Each variable was significantly different than the VT at the last positive, positive/negative, and negative stages. Figures 1-5 graphically present the individual outcomes at VT and the three indices of the Rainbow Passage and Pledge of Allegiance TTs.

Table 3.

Mean (± SD) of Outcome Measures at VT, Last Positive, Positive/Negative, and Negative Responses During the Pledge of Allegiance Talk Test.

Variables	@ VT	@ +	@ +/-	@ -
VO_2 (ml • min^{-1} • kg^{-1})	18.0 ± 1.0	22.2 ± 4.8*	24.8 ± 6.0*	27.3 ± 7.4*
% VO_2peak	64.9 ± 3.3	78.4 ± 3.0*	87.8 ± 3.1*	96.8 ± 1.4*
HR (beats • min^{-1})	126.5 ± 4.8	138.5 ± 6.9*	147.1 ± 5.9*	162.2 ± 4.6*
% HRpeak	73.8 ± 2.4	80.5 ± 2.8*	85.7 ± 2.3*	94.6 ± 1.6*
V_E (L • min^{-1})	33.2 ± 3.0	45.3 ± 4.9*	52.0 ± 5.3*	60.5 ± 5.5*
% $V_E$peak	53.1 ± 3.2	71.0 ± 4.8*	81.9 ± 4.9*	94.2 ± 3.4*
Vf (breaths • min^{-1})	24.1 ± 1.6	27.3 ± 1.9*	29.0 ± 2.1*	31.8 ± 2.1*
% Vfpeak	73.6 ± 2.8	80.4 ± 2.5*	84.7 ± 2.1*	92.2 ± 1.2*
RPE	3.1 ± 0.4	4.0 ± 0.5*	5.0 ± 0.5*	6.6 ± 0.5*

* indicates significant difference using a Tukey comparison vs. VT

When comparing the outcomes of the Rainbow Passage to the Pledge of Allegiance at each stage, there was no significant difference between the two different statements for any of the physiologic variables.

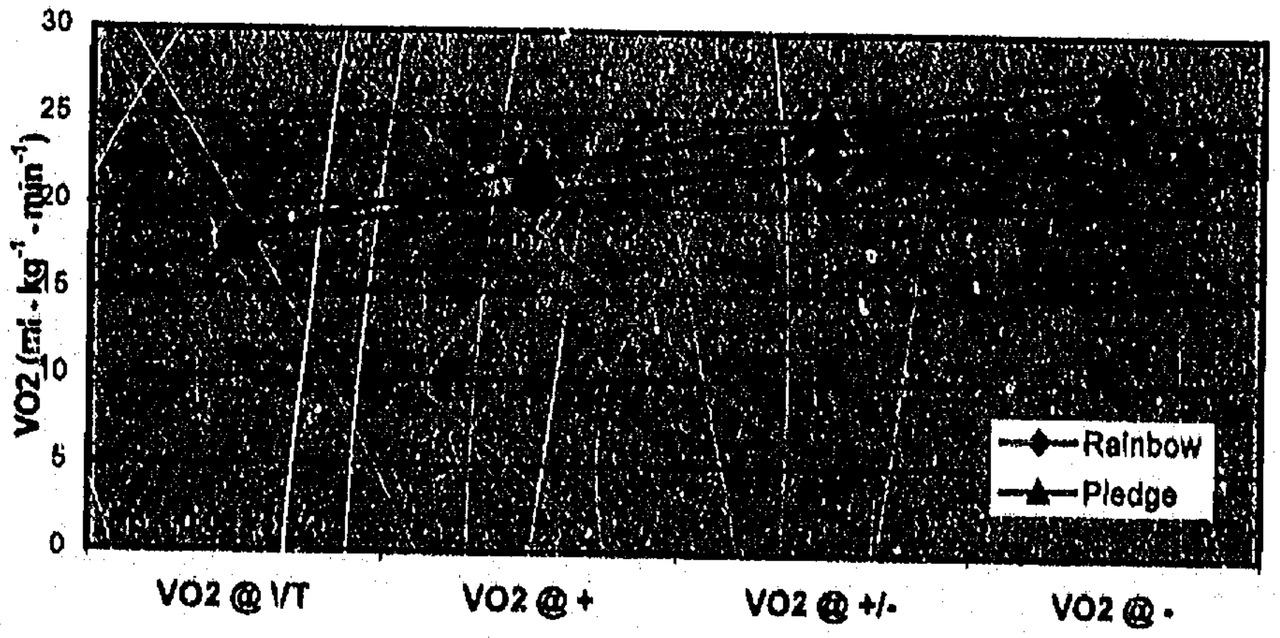

Figure 1. Oxygen consumption compared to VT, last positive, positive/negative, and negative responses during the Talk Tests.

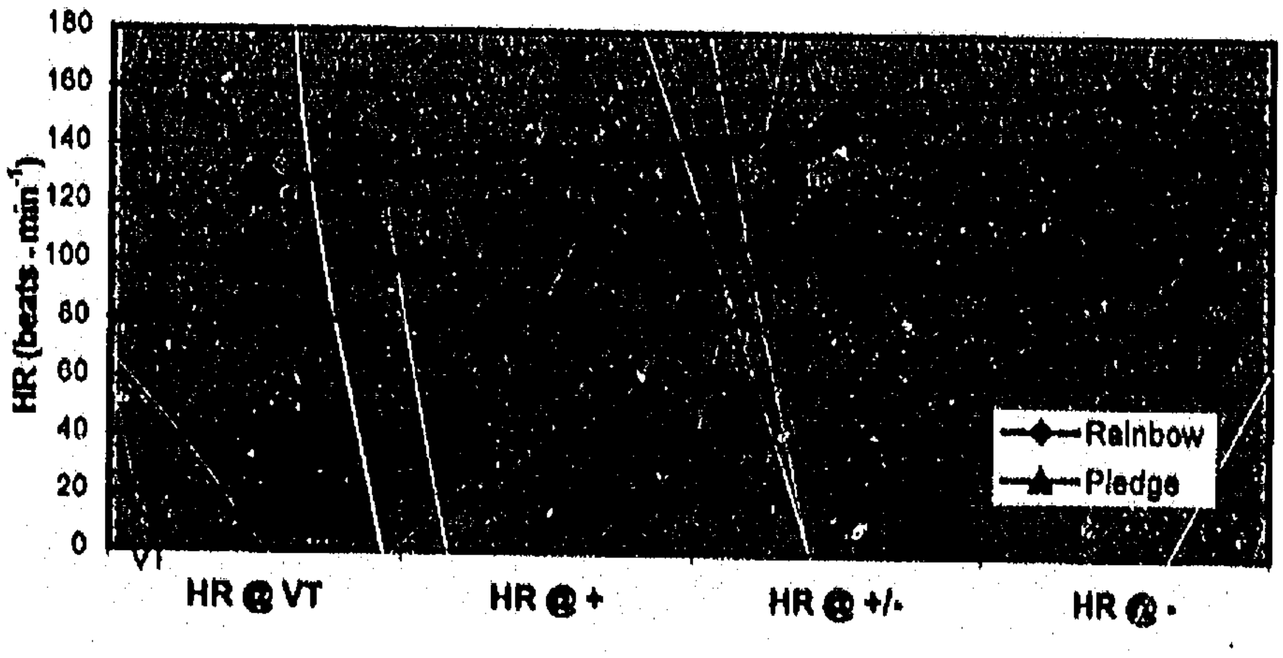

Figure 2. Heart rate compared to VT, last positive, positive/negative, and negative responses during the Talk Tests.

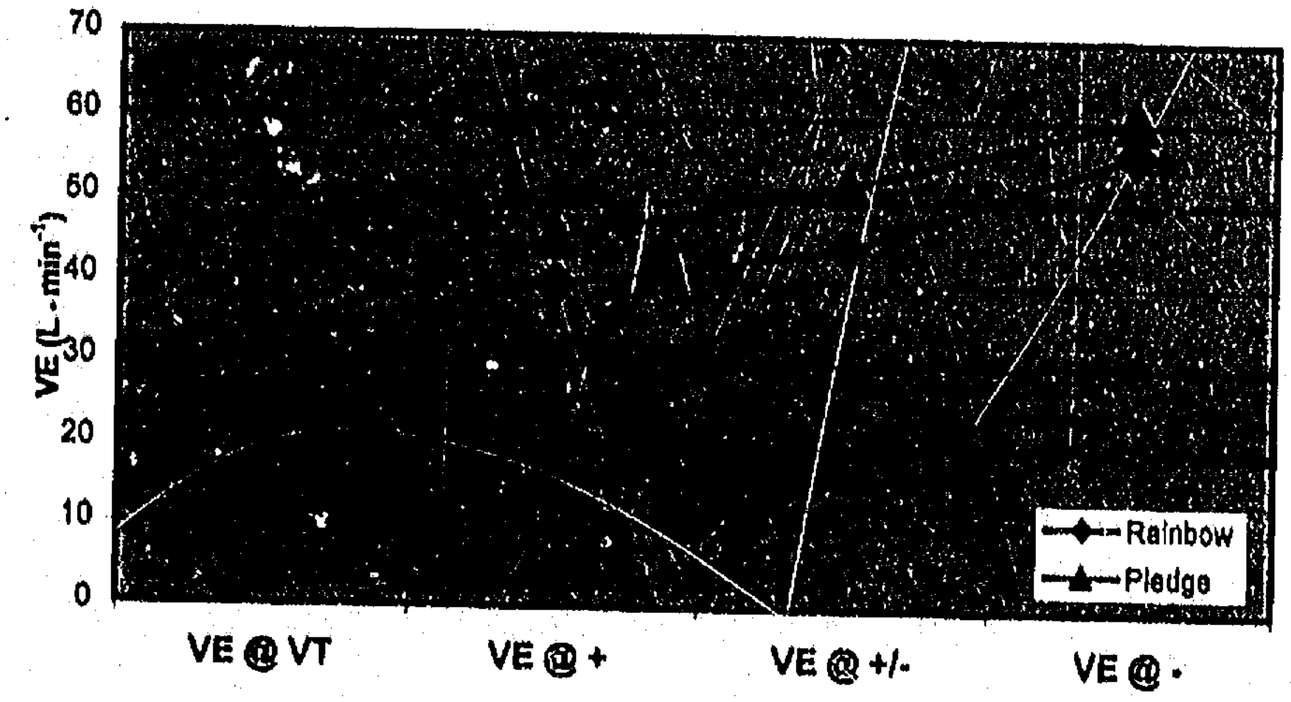

Figure 3. Ventilation compared to VT, last positive, positive/negative, and negative responses to the Talk Tests.

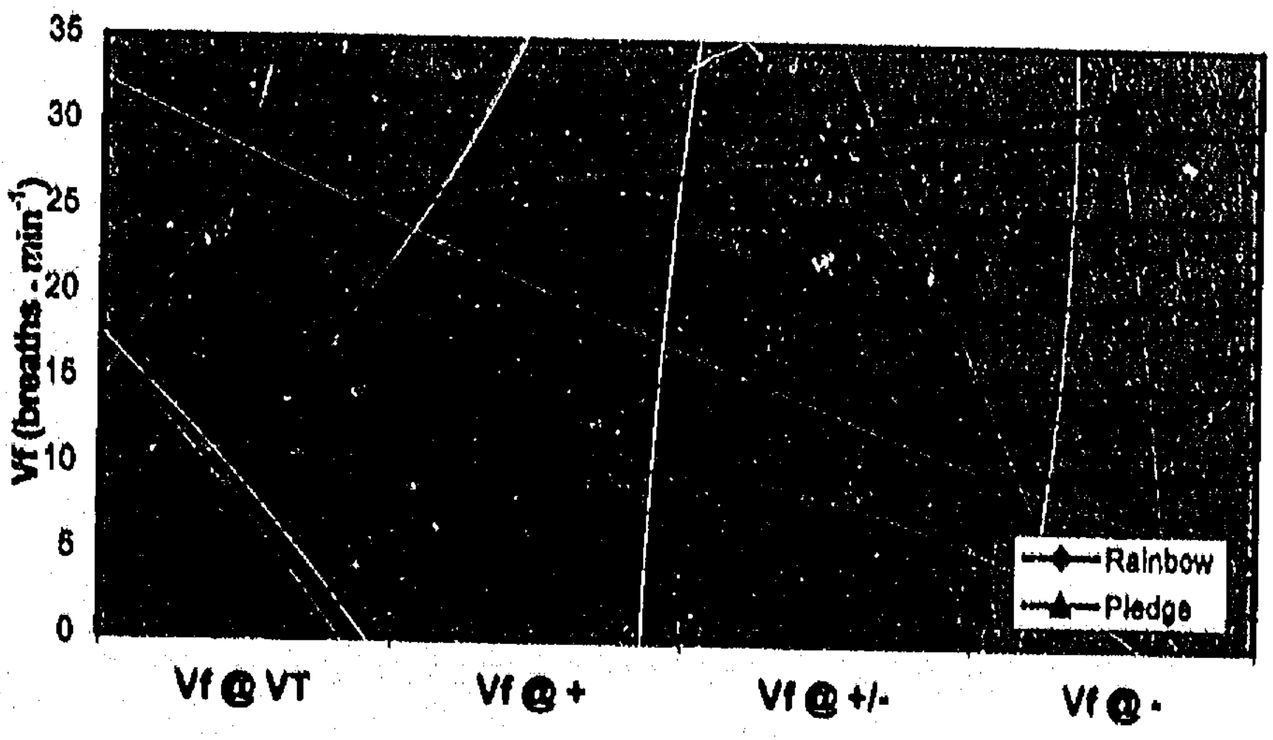

Figure 4. Ventilatory frequency compared to VT, last positive, positive/negative, and negative responses during the Talk Tests.

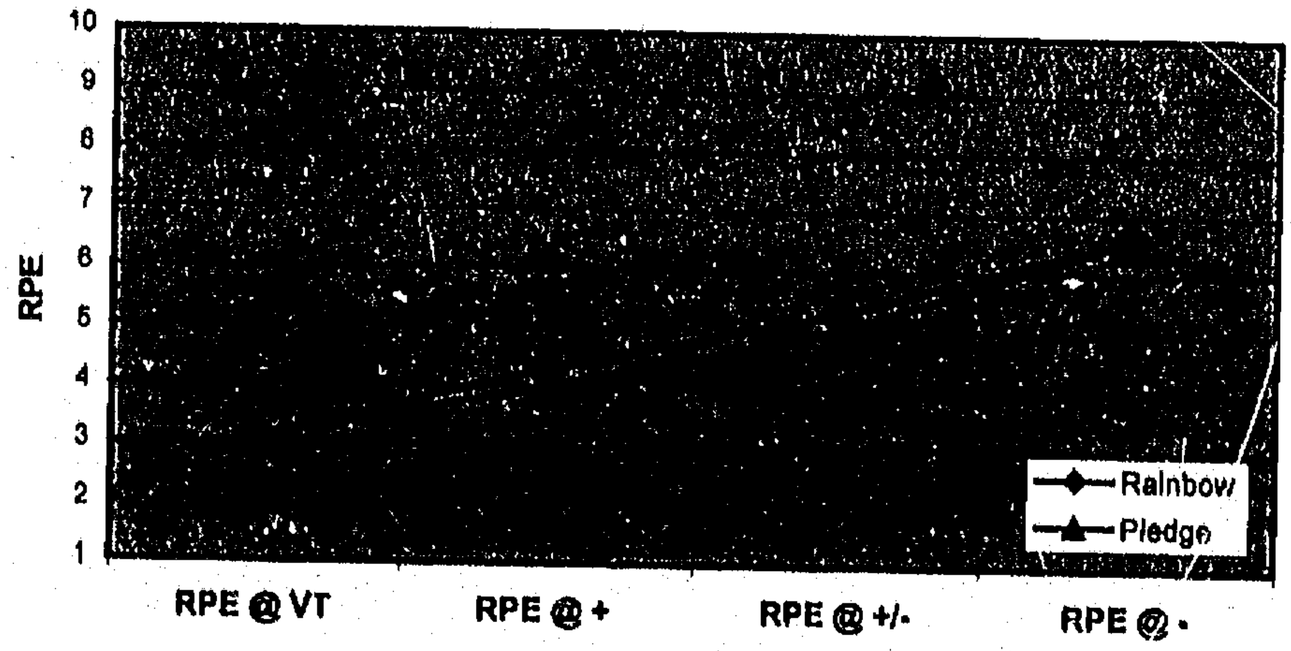

Figure 5. Rating of Perceived Exertion to VT, last positive, positive/negative, and negative responses during the Talk Tests.

DISCUSSION

The initial reason for conducting this study was to determine the relationship of the TT to the VT in a healthy, yet sedentary population. This study replicated Dehart-Beverley et al. (11) with a few additions. They evaluated a healthy, young, and active group. Since the TT is a potential intensity marker for exercise, the target audience is the sedentary public. Secondly, the current study added another speech selection. Dehart-Beverley et al. (11) noted that the 101-word, Rainbow Passage, was potentially not a realistic conversation piece due to its length and the necessity for a cue card. The 31-word Pledge of Allegiance did not result in significant differences between any of the physiological variables at temporally matched stages compared to the Rainbow Passage. However, there were numerically larger values in the Pledge of Allegiance for VO_2, HR, V_E, and Vf. The RPE was the only variable that was not elevated due to the shorter

passage. It is questionable if the latter described limitations affected the lack of significance between the two statements.

The results from this study were not consistent with the results of Dehart-Beverley et al. They concluded that when the ability to talk comfortably became difficult, the individual was exercising at or near their VT (11). The present study indicates that prior to exercise becoming too hard to continue conversing, they have surpassed their VT. In other words, the subject reached this physiological variable before speech was impaired. Figure 6 compares responses in the two studies relative to VO_2. In looking at this one variable, the difference in results are clear. Additionally, the more fit subjects had a perceived exertion of 5.6 ± 1.3 at VT, while the sedentary rated $3.1 \pm .04$ at VT. Dehart-Beverley et al. found that subjects failed the TT at a higher VT, yet the current data reflects the work was easier at the same degree of difficulty.

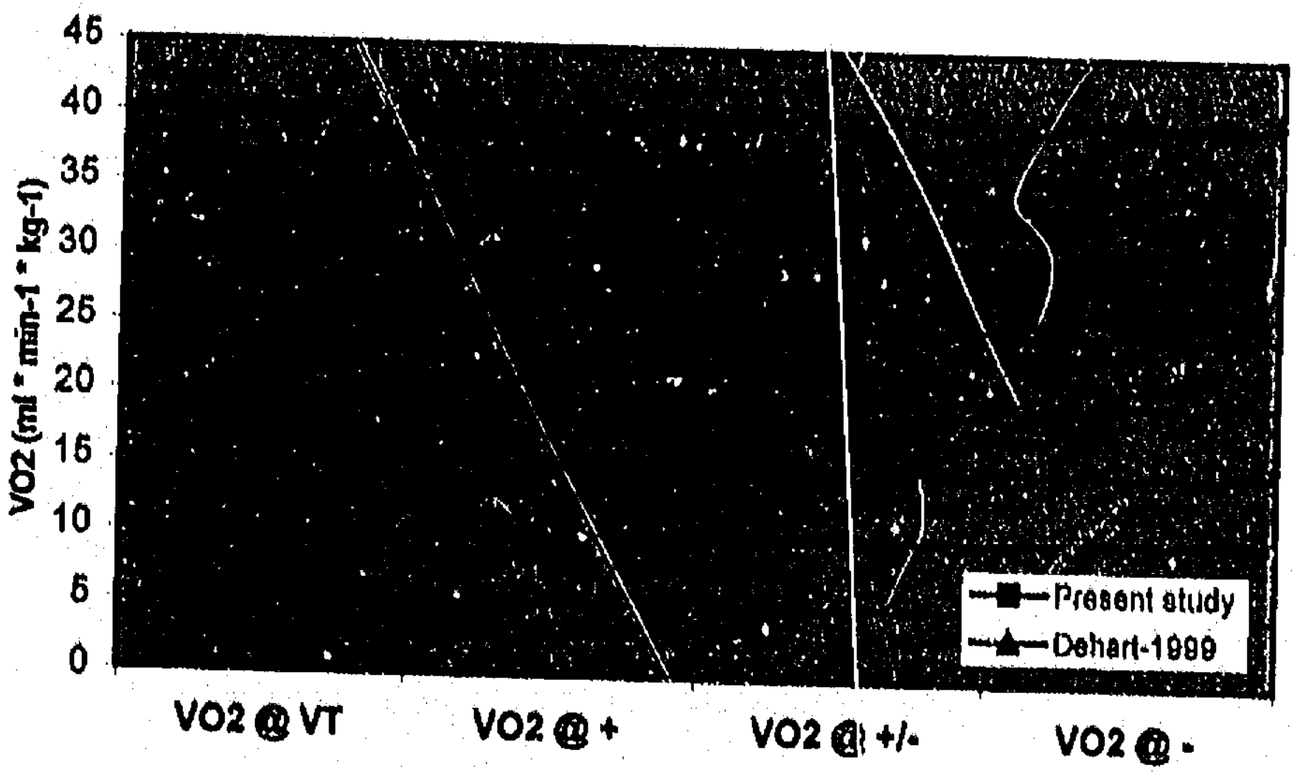

Figure 6. Mean oxygen consumption at VT, last positive, positive/negative, and negative responses of the present study compared to Dehart-Beverley et al.

Misinterpretation of the RPE scale could have resulted in this situation. This was the first time any of the sedentary subjects were exposed to the perceived exertion scale, however the lack of significant differences between the Rainbow Passage and the Pledge of Allegiance suggests a consistent interpretation. Percent VO_2peak and %HRpeak are both higher in Dehart-Beverley et al. at VT versus the last positive and equivocal stages. In the present data, both variables are lower at VT in comparison to the positive and equivocal stage. It seems clear that the present subjects were less fit and overall acted differently than the previous study.

It is obvious that this study is not in agreement with previous findings. There are significant differences at the last positive stage in comparison to VT in the present study, They found the same phenomenon occurring at the equivocal stage. There are many possibilities as to the origin of this problem.

The subjects were unaccustomed to exercise. All were screened to be healthy, but lacking in daily physical activity. Another limitation is the unfamiliarity of motorized treadmill walking to a sedentary, inactive group. None of the subjects had ever used a treadmill before. There is a possibility of lack of habituation being a significant factor. If these people had never used a treadmill, the first test experience, out of three, might have better served as a familiarizing trial. This could have affected the VO_2, HR, V_E, Vf, and RPE. Conversely, there is no statistical significance between the two verbal tests. Over time, these subjects could have become habituated to treadmill walking which would have led to less variance, or more reliable data, between tests.

Secondly, the deconditioned subjects felt it necessary to use handrail support while exercising. This is an important factor in determining differences between the two studies. Several studies have shown that using handrail support will overestimate VO_2 (18-20), as well as HR (18). Even minimal handrail support, such as two fingers, will result in higher oxygen consumption and HR (18). In addition, to those variables, an increase in test time is also ordinarily observed (18-20). The subjects often used greater support towards the end of the test, when the workloads were higher, just as Haskell et al. observed (19). This potentially lengthened the time of one test more than the other, which can lead to inconsistent findings.

Nonetheless, the observed %VO_2peak and %HRpeak at the last positive stage of the TT are still within ACSM's training recommendations (Figures 7 and 8). This has also been found in the previous studies (9-11). This is valid through the positive/negative stage of the current study. The ACSM's guidelines for prescribing exercise are 50-85% of the VO_2peak and 55-90% of HRpeak (3). We found that the positive and equivocal stages of the TT elicited a %VO_2peak of 75.9 and 84.2%, respectively. The %HRpeak for the same stages showed a 79.2 and 86.1%. Our data imply that our subjects were exercising within ACSM's recommendation, although above their VT.

Previous studies suggested that passing the TT was consistent with HR and VO_2 responses within the ACSM guidelines for exercise training (9,10). Although the results of the TT in these studies were not related to the VT, the subjects were consistently within %HR and %VO_2 guidelines for exercise training at both positive and equivocal stages of the TT, regardless of the strategy for producing the speech sample.

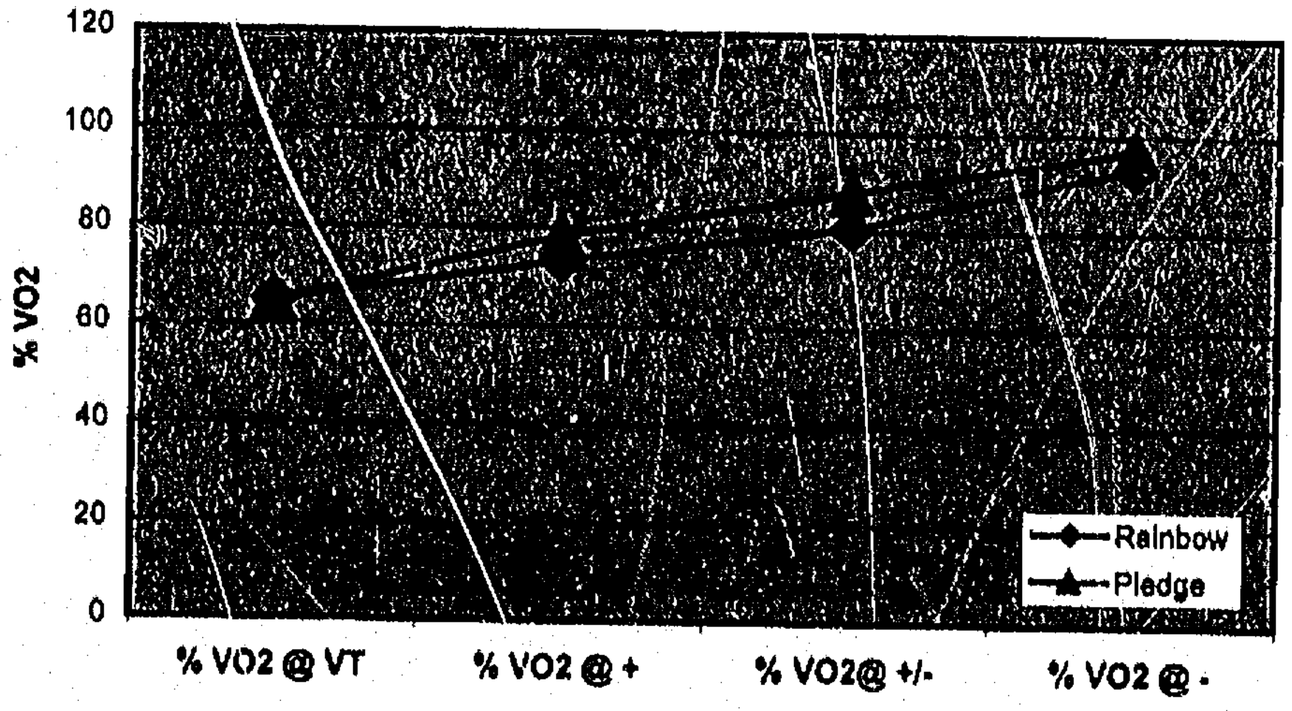

Figure 7. Percentage of maximal oxygen consumption at VT, last positive, positive/negative, and negative responses to the Rainbow Passage and Pledge of Allegiance.

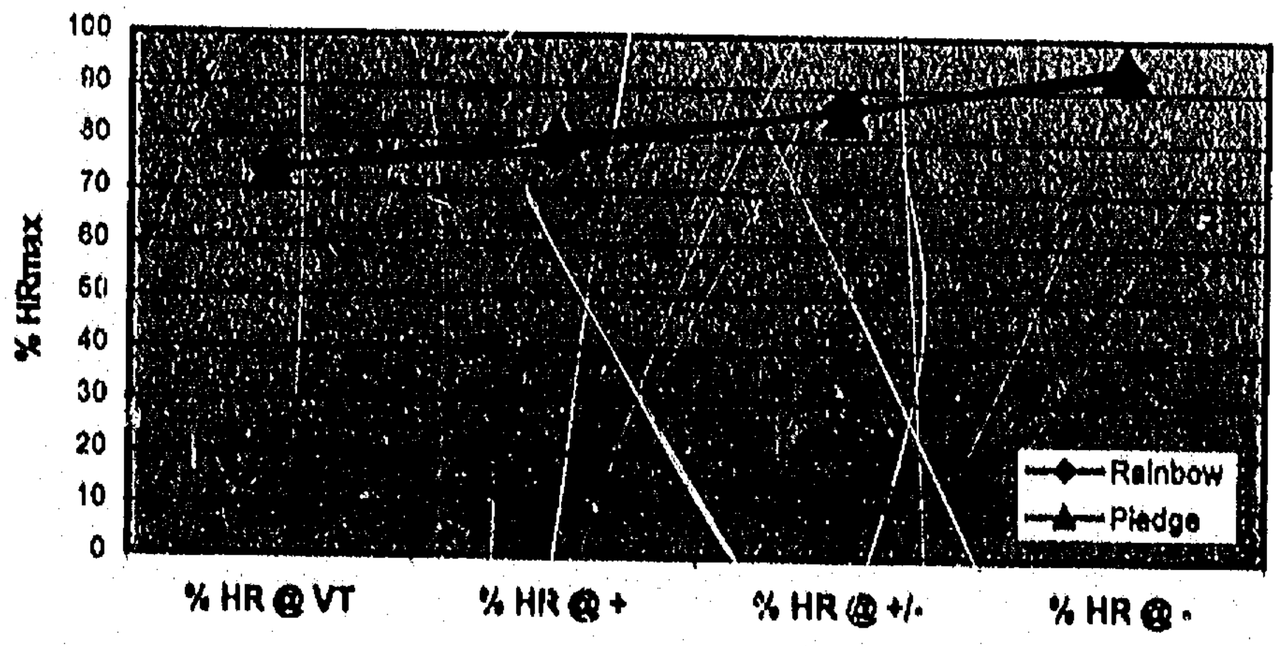

Figure 8. Percentage of maximal heart rate at VT, last positive, positive/negative, and negative responses during the Rainbow Passage and Pledge of Allegiance.

This study needs to be replicated with further changes. With the strength of Dehart-Beverley et al. data, it is possible that this study had too few subjects to see similar changes. If future study is desired, habituation for sedentary subjects by holding practice sessions for treadmill walking as well as wearing the VO_2 apparatuses would be desirable. Only a small number of sessions should be required, otherwise there is a possibility of a training effect on a deconditioned population. Elimination of handrail support throughout is as critical as even a small amount of handrail support will result in changes (18). Lastly, the two speech patterns, plus the gas exchange test, should be used. It is likely that the shorter, more conversational, paragraph will have significant outcomes. It is essential to use a sedentary population because the TT has potential to be an easy way to monitor exercise intensity.

The current study revealed different results from the one prior. It is thought that if subjects are unable to verbally communicate, they are at or above their VT. Even though this did not occur in this study, this is an acceptable method for prescribing exercise, based on ACSM's recommendations. The various limitations, in addition to the solid findings of Dehart-Beverley et al., lead us to believe that the TT is still a potential candidate for prescribing and gauging exercise intensity.

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APPENDIX A

HEALTH HISTORY QUESTIONNAIRE

AHA Health Clubs Risk Factor Screening Tool (12)

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 cathertization
- Coronary angioplasty (PTCA)
- Pacemaker/ICD/rhythm disturbance
- Heart valve disease
- Heart failure
- Heart transplantation
- 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 active
- You are more then 20 pounds overweight

If you check two or more of the following you should consult your health care provider before engaging in exercise. You should probably use a facility with a 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 VENTILATORY THRESHOLD AND THE TALK TEST

I, _____ (name), consent to participate in this research study concerning the relationship between ventilatory threshold and the Talk Test. The Talk Test is an exercise test that will determine how well I am able to communicate or verbalize a passage while exercising at various workloads. To find valid results a number of other physiological test will be measured simultaneously, including, ventilatory threshold, percentage of maximal oxygen consumption, heart rate, and ratings of perceived exertion (RPE).

I have been informed that the tests, which I will undergo, will be performed on a treadmill that is located in the Human Performance Laboratory in Mitchell Hall on the University of Wisconsin-La Crosse campus. I will walk until fatigue or other symptoms prohibit further exercise. During the test, heart rate will constantly be monitored, by wearing a heart rate monitor strapped to my chest. While the gas exchange test is being conducted, I will breathe room air through a scuba type mouthpiece. When the test begins, I will have a four-minute warm-up stage that will be conducted at a fairly light intensity. Following the warm-up, two-minute stages with an increase in grade, will be performed until completion of the test. I understand that every minute of the test my heart rate and RPE will be recorded.

My participation in this study will also involve two additional tests. They will be conducted at the same speed as the first, and again the grade will change every two minutes. A heart rate monitor will be worn to monitor heart rate development during exercise. These tests will be known as the "Talk Test" and warm-up will consist of moderate exercise for four minutes. During every two-minute stage, I will read either a 31 or 100-word passage, which will evaluate how effective I can speak at increasing workloads. Again, heart rate and RPE will be recorded at every minute. I understand the estimated amount of time will be one hour for each test. I also realize I will be able to terminate the either test at any time without penalty.

I have been informed that there are potential risks involved in doing maximal tests, which include, muscle soreness, shortness of breath, abnormalities in heart rate, fatigue, and on rare occasions, serious complications such as a heart attack and even death by stroke. The risk of serious complication is about 1/10,000 in patients with suspected heart disease. As a healthy subject, the complications are expected to be significantly less. I realize that either test will be stopped immediately if complications arise. I have been informed that the investigator is trained in first aid, Cardio Pulmonary Resuscitation, and Advanced Cardiac Life Support. There is a well established emergency protocol in the laboratory.

In participating in this research study, I will gain knowledge on my own fitness levels and how I respond to incremental exercise. The results that are obtained from my participation will facilitate a better individualized exercise prescription for me in the

future. I have been informed that the conclusions gathered from this study may encourage exercise professionals to use the Talk Test to monitor exercise intensity.I consent to presentation and publication of the results. I have been informed that my name and/or identity will not be revealed. All data collected will be maintained in a personal file belonging to Natalie Shafer. I have been informed that only she and the investigator's research committee will have access to that file.

I have read the above information and have been informed of the procedures, anticipated benefits, and risks associated with being a part of this experiment. Any other questions that I have will be answered before I sign this consent form. I have been informed that I can withdraw at any time from the experiment without penalty. If I have further questions I understand that I can contact the principal researcher (Natalie Shafer, 784-9896) or the faculty advisor (Dr. Carl Foster, 785-8687). Any questions I have regarding the protection of Human Subjects may be addressed to Dr. Garth Tymeson (785-8155) Chair of University of Wisconsin-La Crosse Institutional Review Board for the Protection of Human Subjects.

Signed: _____ Date: _____

Researcher: _____ Date: _____

APPENDIX C

TREADMILL PROTOCOLS

Modified Balke Protocol - Females

Stage (2 min)	Speed ($m \cdot hr^{-1}$)	Grade (%)
Warm-up*	2.0	0
I	3.0	0
II	3.0	2.5
III	3.0	5
IV	3.0	7.5
V	3.0	10
VI	3.0	12.5
VII	3.0	15
VIII	3.0	17.5

* warm-up consisted of 4 minutes

Modified Balke Protocol – Males

Stage (2 min)	Speed ($m \cdot hr^{-1}$)	Grade (%)
Warm-up*	2.5	0
I	3.5	0
II	3.5	2.5
III	3.5	5
IV	3.5	7.5
V	3.5	10
VI	3.5	12.5
VII	3.5	15
VIII	3.5	17.5

* warm-up consisted of 4 minutes

APPENDIX D

RATING OF PERCEIVED EXERTION

Borg's Rating of Perceived Exertion Scale (2)

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" (15)

"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 (15, p. 127).

APPENDIX F

PLEDGE OF ALLEGIANCE

"Pledge of Allegiance"

"I pledge allegiance to the flag of the United States of America and to the Republic for which it stands, one Nation under God, indivisible, with liberty and justice for all."

APPENDIX G

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Introduction

The United States is becoming more vastly populated with obese individuals. Lack of exercise and poor nutritional habits are two factors that cause obesity. Sedentary individuals can eventually become obese if appropriate precautions are not taken. To combat obesity and other chronic diseases that poor caloric balance bring, exercise must be initiated. If a middle-aged or older individual, over 45 years of age, is sedentary or has significant risk factors for coronary heart disease (CHD), they should contact their physician before implementing an exercise regimen (1).

The individual then needs to concentrate on four basic principles of an exercise program, which are: frequency, duration, intensity, and mode. Intensity is the most difficult element to monitor because, for most methods of monitoring exercise intensity, additional items or knowledge is needed. Intensity can be determined a number of ways including, but not limited to: ventilatory threshold (VT), anaerobic threshold (AT), lactate threshold (LT), percentage of VO_2max (%VO_2max), percentage of HRmax (%HRmax), percentage of HR reserve (%HRR), Rating of Perceived Exertion (RPE), and the Talk Test (TT).

The RPE scale and the TT are the only two of the above listed that do not require maximal testing; therefore, they are subjective measures of intensity. Brawner and Keteyian (2) suggested that 48% of their sedentary subjects preferred subjective methods

instead of objective. To date, RPE is the most widely recognized subjective measure of exercise training intensity

Heart Rate

The most common and safe way of determining HR is through a pulse count or HR. The pulse rate is a valuable indicator of exertion and is frequently used in exercise prescription. There are large individual differences in HRmax, which present problems with this particular method, unless HRmax is objectively determined. Dishman et al. (3) reported that age predicted HR could be up to 10 to 15 beats • min^{-1} above or below true HRmax. Problems such as medications and psychological states can also effect HR.

Is a pulse count a valid measure? There are data demonstrating that during carotid palpation there is a significant drop in HR (4). The drop in HR is thought to happen because the pressure on the baroreceptors remove sympathetic stimulation, but increases parasympathetic, causing a lower HR. In most studies, cardiac rehabilitation centers have been used. Therefore educating patients and staff in the techniques is important for consistency. On the contrary, Oldridge, Haskell, and Single (5) discovered that carotid palpitation is permissible to determine resting, exercise, and post-exercise HR. In another study, no significant differences were observed in post-exercise HR, between subject palpated, telemetry, or electrocardiographic HR counts at 80-90% training intensity (6). With this discrepancy in literature findings, cardiac patients must be closely monitored for correct intensity levels.

Heart rate formulas are readily available and are of value, but at the same time, they can be misleading. Goldberg, Elliot, and Kuehl (7) used the age predicted,

Karvonen method, and measured HRmax formulas by detecting VT. To determine which was more effective, they compared the three HR methods with three varying degrees of fitness abilities; low, average, and high. Seventy-seven percent of the Karvonen formula resulted in a level that was unsuitable for sustained aerobic conditioning for the low and average fitness levels. They concluded that the Karvonen equation was significantly higher than VT among the above groups, therefore prescribing exercise above 77% is not recommended. The measured maximal and the age predicted formulas resulted in HRs near or below the VT.

Talk Test

The TT is widely recommended by health care professionals as well as health related organizations (8-11). There is little data to support the use of the TT. Only three studies concerning the TT have been published and of those, two are abstracts.

Brawner, Keteyian, and Czaplicki (12) tested sedentary adults, and measured HR and VO_2max by using a symptom limited graded exercise test (SLGXT). The subjects then exercised at a comfortable pace that allowed them to carry on conversation (TT). This was also done on an outside track and the subject responded to a cassette player with headphones that had a standardized verbal passage. Heart rates were compared between the SLGXT and the field test. The TT usually generated an intensity which fell within the ACSM guidelines, 60-90% VO_2max, for cardiovascular fitness.

The same group repeated a similar study two years later in 1997 (13). Testing sedentary adults again, they used different modalities to determine if the TT was suitable for exercise prescription. The protocol was similar to the previous studies in that the

subject went through a SLGXT, where HR and VO_2 were measured and then conducted a TT on a dual-action cycle ergometer. They were asked to exercise at the fastest pace that still allowed conversation to take place (TT), using the headphone and cassette tape. The VO_2 and HR intensity range of 50-85%, dictated by ACSM, was met by both treadmill and the bike tests. The results indicated that the TT is an appropriate way for sedentary adults to train using those two modalities. These variables remained within ACSM guidelines for prescription.

Recently, Dehart-Beverley et al. (14) studied 28 college students during two randomly ordered incremental treadmill protocols. One test was conducted with respiratory gas exchange and the other used a standard paragraph which was recited at the end of each stage of the exercise protocol. After each recitation of the standard paragraph, the subject was asked, "can you still talk comfortably?" to which the subject could answer "yes" (measuring that they could still talk reasonably comfortable), "I am not sure", or "no" (meaning that they could not talk reasonably comfortable). The points within the exercise protocol corresponding to the last time the subject responded "yes" (+), the first time they responded "I am not sure" (+/-), and the first time they responded "no" (-) were compared to physiologic responses observed during the same exercise protocol, but with monitoring respiratory gas exchange. Table 1 lists mean (± SD) values for $\%VO_2max$, %VT, %HRmax, and RPE at these three indices of the TT.

Table 1. Mean (± SD) for variables at each stage of previous Talk Test results (14).

	% VO_2max	%VT	%HRmax	RPE
+	75.4 ± 9.5	94.4 ± 6.5	85.3 ± 7.6	5.2 ± 1.6
+/-	79.1 ± 9.9	98.9 ± 6.0	87.8 ± 6.7	5.8 ± 1.6
-	87.0 ± 8.0	108.3 ± 5.4	92.3 ± 5.6	7.2 ± 1.7

The results suggested that the last positive stage of the TT was within conventionally accepted markers of exercise prescription and at a slightly lower intensity than the VT. The equivocal stage of the TT corresponded almost exactly to the VT and the first negative stage of the TT was consistently at an intensity exceeding the VT, as well as conversational markers of exercise prescription. Dehart-Beverley et al. indicated that "at the point at which [they] are either last passing the Talk Test or beginning to struggle with the ability to talk comfortably is essentially equivalent to their VT" (14, p. 36). As did the previous two studies, Dehart-Beverley et al. showed that at the last positive or equivocal stages of the TT, the %HRpeak, which was 87.8%, fell into the upper limit of ACSM's guidelines.

Anaerobic / Ventilatory Threshold

There is a point during incremental exercise when the fundamentally linear response to exercise disappears. It is at this point, that questions arise concerning VT, AT, and LT. Each is a specific phenomenon, and, although not perfectly correlated with each other, they all reflect the same energy system.

Ventilatory threshold is used interchangeably with AT, but they do have separate meanings. These two terms are linked because they often occur more or less

simultaneously. Wasserman (15) describes anaerobic threshold as the time during incremental exercise when oxygen is not readily being delivered to the mitochondria. This leads to oxygen demand being greater in the active muscles, which occurs as a result of anaerobic conversion of pyruvate to lactate. The lactic acid is buffered by bicarbonate, which in turn produces CO_2. The non-linearity is known as VT or AT. The extra CO_2 causes an increase in ventilation.

Skinner and McLellan (16) use the same concept, yet a different choice of terms. They correlate the points that AT, VT, and LT occur. When the exercise intensity approaches 40-60% VO_2max, VO_2 and HR are still linear, but there is a rise in lactate of approximately 2 mmol $\cdot L^{-1}$. There is also non-linearity occurring due to the increased ventilation and VCO_2, which is what they term aerobic threshold (16). This is synonymous with Wasserman's (15) definition of AT. Skinner and McLellan (16) define anaerobic threshold as the point in which ventilation rises disproportionately to VCO_2 and lactate is about 4 mmol $\cdot L^{-1}$ and rapidly increases until max is achieved.

Ventilatory threshold has also been used as a marker of training intensity. Detection of AT and VT can be done using equipment required for a VO_2max test (gas exchange/metabolic cart); therefore the process to determine VT is non-invasive. Davis et al. (17) looked at where the AT fell while using different modalities of exercise; arm crank, leg cycle, and treadmill. The mean time in which the AT was reached was 11.1 minutes and, in all subjects, AT occurred during the walk phase. There was no significant difference in AT values for the leg cycling and treadmill walking, but the AT was significantly lower during arm cranking.

Londeree (18) conducted a meta-analysis to determine if lactate and VT are equivalent in endurance training. His study included all levels of ability, from sedentary to highly conditioned. The sedentary group made significant improvements over the control group, but no significant difference in training intensities. In fact, the sedentary groups improved more than the high fitness groups. The conditioned subject groups illustrated smaller changes in threshold than did the sedentary. This is likely to have happened because when sedentary people start an exercise regimen, physiological adaptations are being made to a new lifestyle. Londeree (18) concludes that the sedentary population should train at or above the VT to produce a training effect. Clearly, training above VT will provide a necessary training effect on the conditioned person, however, could this be dangerous in the sedentary population.

VO_2max

A maximal aerobic exercise test will measure cardiorespiratory fitness. The VO_2max is the single most well known measure of aerobic fitness (19, 20). The term VO_2max is described as the amount of oxygen the body can take in, transport, and use while exercising.

Relative percentages of VO_2max have been used as the criteria for determining exercise training intensity. Meyer, Gabriel, and Kindermann (21) found that highly conditioned individuals needed 75% VO_2max to train above the AT. Workloads below 60% VO_2max did not produce a training effect. This was established on a highly active population, so greater than 75% VO_2 could produce an inaccurate exercise prescription in the sedentary population.

As an intensity marker, VO_2max can be used in combination with AT, %HRR, and RPE. Rating of Perceived Exertion can be interpreted into a percentage of VO_2max. For example, a RPE of 12 is approximately equal to 50% VO_2max. However in 1997, Whaley et al. (22) investigated the validity of perceived exertion during exercise tests. They indicated that using the RPE scale will underestimate intensity. They reported that a RPE of 12 equaled 76% of VO_2max.

In a study using AT to predict %VO_2, Davis et al. (17) found that different modes will produce variable intensity levels, depending on the size of the muscle group being worked. The VO_2max values attained during arm cranking and leg cycling were 59 and 92% of the treadmill values (17). The arm cranking values were drastically lower, because it uses a smaller group of muscles and leads to fatigue more quickly than that of treadmill running, which incorporates large muscle masses.

Rating of Perceived Exertion

In dealing with a sedentary population, it is important to note that these individuals are not familiar with detection of intensity ranges. Rating of Perceived Exertion allows the subject to place a number, 6-20, to identify their levels of exertion based on all parts of the body. The original RPE scale has been modified to 0-10 for the present study (23, 24).

There are numerous studies that correlate RPE values to other exercise intensity gauges such as HR, AT, VT, LT, and VO_2max. A general guideline is during exercise RPE should range from 11-13 in sedentary populations. Borg, Hassmen, and Langerstrom (23) compared RPE in arm and leg exercise to conclude that at 100 W of

exercise, legs and arms are at an RPE of 12.82 and 18.19, respectively. The arm exercise was much more difficult since there is less adaptation to those movements. Whaley et al. (22) noted that healthy and cardiac patients reported RPE out of the following ranges; a RPE of 12-13 equaled 60% of HRmax and 15-16 was 80% HRmax.

Anaerobic threshold is another common term associated with a RPE scale. It is thought to provide a better basis for exercise prescription than that of %VO_2max or HR. Purvis and Cureton (25) found that at AT, the mean RPE, according to Borg's 15-point scale, ranged from 13.1 to 14.2 for females and males, which correspond to "somewhat hard". This verbal anchor matches the physiological changes that are taking place. This should be the intensity just below which feelings of heavy, uncomfortable breathing and muscular fatigue occur (25).

Rating of Perceived Exertion is important for the sedentary population because the scale is easy to understand. Dishman et al. (3) experimented on a sedentary group by providing feedback of their RPE during an 800-meter walk/jog. A SLGXT was done prior to obtaining the correct data for interpretation of RPE at specific intensities. Using Borg's 6 to 20 point category scale, the RPE observed at target HR were 11 to 16. When RPE and HR were fedback to the participants, they were better able to maintain appropriate training HRs. Many psychological events occur when being tested; therefore, RPE may be a better marker of overall judgement than HR, which can fluctuate in testing situations.

Summary

In retrospect, every exercise program needs to contain an intensity regulating method, whether it is subjective or objective. Subjective measures tend to be more reliable when dealing with a sedentary or inactive population. With more research being conducted on the TT, it will hopefully become a more widely used method. Two of the major advantages of using the TT are: it requires no costly, technological devices and prior exercise knowledge is not demanded.

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