UNIVERSITY OF WISCONSIN-LA CROSSE

Graduate Studies

TRANSLATION OF EXERCISE TEST RESPONSES TO EXERCISE TRAINING IN A CLINICAL SETTING

A Manuscript Style Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Clinical Exercise Physiology

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TRANSLATION OF EXERCISE TEST RESPONSES TO EXERCISE TRAINING IN A CLINICAL SETTING

By Miranda L. Menke

We recommend acceptance of this thesis in partial fulfillment of the candidate's requirements for the degree of Master of Science, Clinical Exercise Physiology.

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ABSTRACT

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The Talk Test (TT) is a subjective sub-maximal exercise test based on a subjects' ability to speak comfortably during exercise and has been of proven value for exercise prescription. This study was designed to test the hypothesis that responses observed during the TT could be reduced/translated and used to define absolute training intensity in clinical populations. Patients (N=14) performed an incremental exercise test, with the TT performed every 2-minute stage. Patients rated their speech comfort after reciting a standardized paragraph. A response of anything but “yes” was considered the EQ stage, with all stages preceding this as “positive” stages. Subsequently, subjects performed randomly ordered 20-minute steady-state exercise bouts at the absolute exercise intensity associated with EQ, LP, LP-1 & LP-2 stages of the incremental test. Measures of speech comfort, heart rate and RPE were acquired every 5 minutes. The 20-minute exercise training bout was fully completed by: EQ (N=1), LP (N=8), LP-1 (N=13) and LP-2 (N=14) patients. At LP-1, speech was comfortable for 13/14 patients through 15 minutes. The results demonstrate that the LP-1 stage of the TT appears to be an appropriate absolute exercise training intensity for patients in Phase II & III cardiac rehabilitation programs.

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INTRODUCTION

When working with new patients in cardiac rehabilitation, exercise intensity is the most difficult element of exercise prescription to define. Prescribing too high of an intensity for patients can lead to noncompliance with the exercise program or predispose toward catastrophic events (Foster et al., 2008). The current ACSM (2010) recommendation for exercise prescription for cardiac patients is an intensity 40-80% of heart rate reserve, VO_2 reserve, or VO_2 peak. The ACSM also recommends an exercise intensity ten beats per minute below the ischemic threshold in patients capable of developing exertional ischemia. However, with these recommendations a maximal exercise test is needed in order to determine maximal exercise capacity and heart rate (HR), which typically requires the presence of a physician. Results from maximal exercise testing can be compromised by the use of handrails, (Berling 2006), whether the test is symptom limited, and by temporal discordance with medications. Although there are methods for translating exercise tests to absolute exercise intensity (Foster et al., 1986, Foster et al., 1991, Foster & Thompson, 1991); it is not inherently easy to derive absolute training intensities from conventional exercise testing.

An alternative way of prescribing exercise is by using the Talk Test. The Talk Test is a subjective sub-maximal test that is based on the ability to speak comfortably. The Talk Test responses have been shown to be well correlated with ventilatory threshold (VT) in populations such as healthy students (Dehart-Beverly et al., 2000), sedentary adults (Shafer et al., 2000), well-trained adults (Recalde et al., 2002), and even patients

with cardiovascular disease (Voelker et al., 2002). The majority of these studies show that when comfortable speech is possible, the intensity is below ventilatory threshold. They also showed that at the equivocal stage, the first stage in which the response to "Can you speak comfortably?" is anything but "yes", the exercise intensity approximates the intensity of the ventilatory threshold. Cannon et al. (2004) have demonstrated that the last positive stage of the Talk Test preceded the onset of ischemia. This suggests that exercising at an intensity at which comfortable speech is possible and is likely to be within safe limits (Foster et al., 2008).

Numerous studies have also shown the consistency of the Talk Test. Foster et al. (2008) studied responses to manipulations of ventilatory threshold and observed that the Talk Test responded appropriately when the VT was experimentally increased and decreased. Persinger et al. (2004) studied the consistency of the Talk Test on different modes of exercise and found that the treadmill and cycle ergometer produced similar and consistent results using Talk Test responses to determine VT.

Just as with a maximal test, effective clinical practice requires the ability to translate results from incremental testing to steady-state exercise training. Foster et al. (2009) studied the reduction needed from incremental exercise Talk Test results to exercise training sessions in sedentary adults. They found that reducing exercise intensity to the workload of the stage preceding the last positive (LP-1) TT result during exercise testing gave appropriate responses related to ACSM recommendations during steady-state exercise. Jeanes et al. (2010) reported similar results with active adults, observing the LP and LP-1 stages during incremental exercise gave appropriate responses during exercise training.

The Talk Test has been shown to consistently correlate with the ventilatory threshold, to respond appropriately to changes in ventilatory threshold, and to respond appropriately during different modes of exercise, in a variety of populations. It also has been shown as an appropriate means of translating incremental exercise test results into steady-state exercise training workloads in both sedentary and active adults. What has yet to be seen is the translation of incremental exercise test results to steady-state workloads in a clinical population. This study was designed to determine if the reduction needed to prescribe appropriate steady-state training workloads from incremental testing works in cardiac rehabilitation patients as it does in healthy individuals. In this study the hypothesis tested was that the appropriate exercise responses will be seen in workloads associated with the LP -1 and LP-2 stages of incremental exercise testing.

METHODS

Subjects

Fourteen Phase II or III cardiac rehabilitation patients were recruited as subjects. Patients participating in this study had completed at least three weeks of cardiac rehabilitation to habituate to treadmill or cycle ergometer exercise, as well as to establish clinically stability (Table 1).

Table 1. Descriptive characteristics of the subjects (Mean ± Standard Deviation)

	Male (N=13)	Female (N=1)	Total (N=14)
Age	70 ± 9.9	71	70.1 ± 9.5
Height (cm)	179.5 ± 7.6	157.5	177.9 ± 9.3
Weight (kg)	90.7 ± 19.5	85.7	90.3 ± 18.8
BMI	28.4 ± 4.3	34.6	28.9 ± 4.4

Procedure

After approval from the University of Wisconsin-La Crosse Institutional Review Board for the Protection of Human Subjects as well as Gundersen Lutheran's Human Subjects Committee, all subjects provided written informed consent before testing. Each subject completed five sub-maximal treadmill or cycle ergometer tests depending on their preferred mode of activity, all of which were completed as part of their rehabilitation program. The first test was an incremental exercise test measuring Talk Test responses. The initial exercise intensity was approximately two METS and was increased by 0.5 METS per stage. In this test the subjects were asked to recite a standard paragraph

provoking stimulus (the 'Pledge of Allegiance') every two minutes followed by answering the question "Can you speak comfortably?" The stage in which the subject first responded with anything but 'yes' was considered the equivocal stage (EQ) and all preceding this were 'positive' stages. This test was continued until subjects reached the EQ stage. In a variety of other studies the EQ stage has been shown to approximate the intensity of the ventilatory threshold (Beverly-Dehart et al., 2000, Recalade et al., 2002, and Voelker et al., 2002) and to occur in advance of the ischemic threshold (Cannon et al., 2004). Physiological responses including heart rate and rating of perceived exertion (RPE) were also monitored. This first test defined the workloads for the remaining exercise tests which were performed at the absolute intensity of the EQ stage, at the last positive (LP) stage, and one (LP-1) and two (LP-2) stages proceeding the LP stage (Foster et al., 2009 and Jeanes et al.,2010).

The remaining exercise tests were all 20-minute steady-state bouts and were performed in random order. Test workloads were based on the subject's incremental test. Throughout each test the Talk Test was measured by having the subject recite the 'Pledge of Allegiance' every five minutes and answering the question "Can you speak comfortably?" Their responses were assigned a number accordingly: "yes"=1, "equivocal"= 2, and "no"=3. The steady-state exercise bouts were discontinued when the patient could not speak comfortably or when the individual indicated a desire to stop the bout because of a high score of effort. Physiological (HR and RPE) responses were also monitored every five minutes. Responses from the exercise tests were compared to test the hypothesis that the appropriate responses for exercise training for cardiac patients would be found during the LP-1 and LP-2 stages of the Talk Test.

Statistical Analysis

Descriptive statistics were used to characterize the Talk Test, RPE, and heart rate responses from each Talk Test trial. Given the explanatory nature of the protocol, comparisons of mean values were not performed.

RESULTS

The number of patients completing each stage of the four steady-state trials is displayed in Figure 1. During the LP-2 trial, 14 patients completed the 20-minute exercise bout. During the LP-1, 13 subjects were able to finish the entire trial. However, in the LP trial, patients began quitting after 10 minutes, and only eight were able to complete the full 20 minutes. Correspondingly, in the EQ trial, patients began quitting after 5 minutes, and only one subject was able to complete the trial in full.

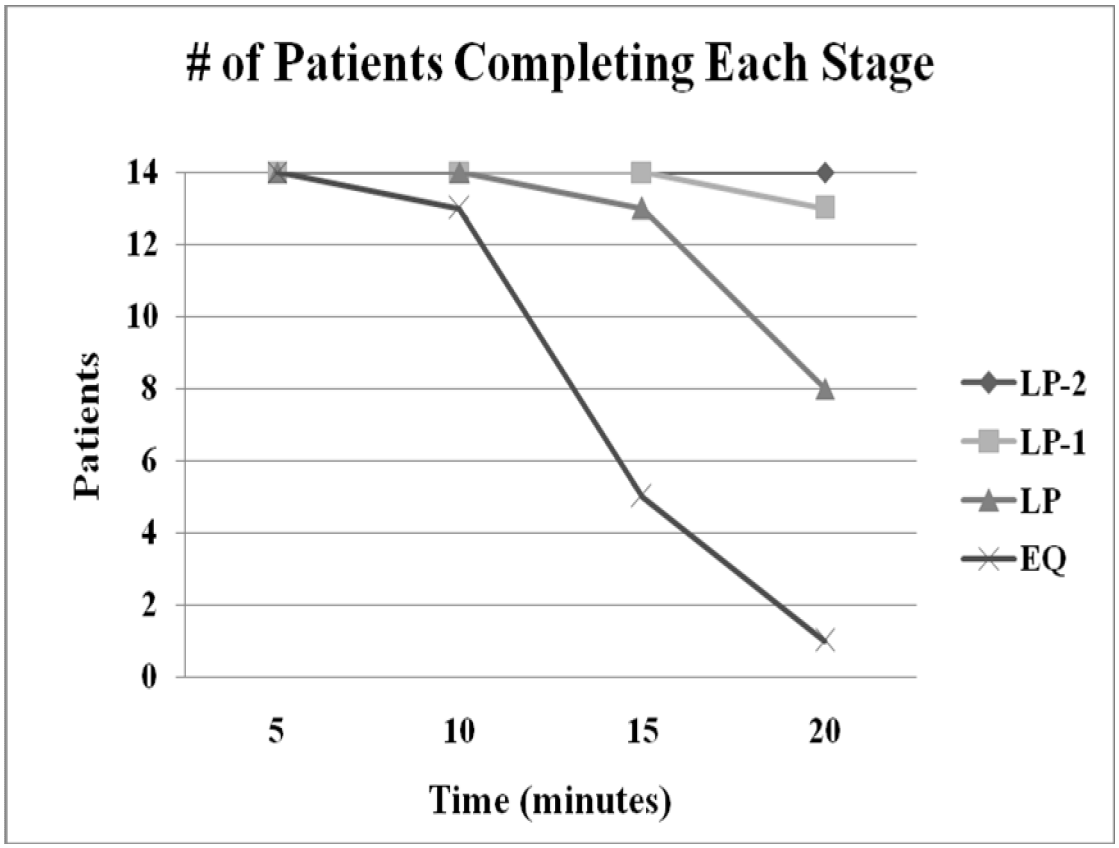

Figure 1. Ability of subjects to complete the stages of the four Talk Test trials.

The Talk Test responses during each trial are shown in Figure 2. When intensity was equal to that of LP-2, most of the patients were able to speak comfortably throughout the trial with only one reporting equivocal for the TT in the final two stages. During the LP-1 trial, comfortable speech was possible for most patients during the exercise bout with only one subject reporting inability to speak comfortably and subsequently being unable to finish the last five minutes of the bout. Comfortable speech ability was less evident in the LP trial with the inability to speak comfortably beginning after 10 minutes for some patients. The majority of subjects reported eqivocal or uncomfortable speech ability during all stages of the EQ trial.

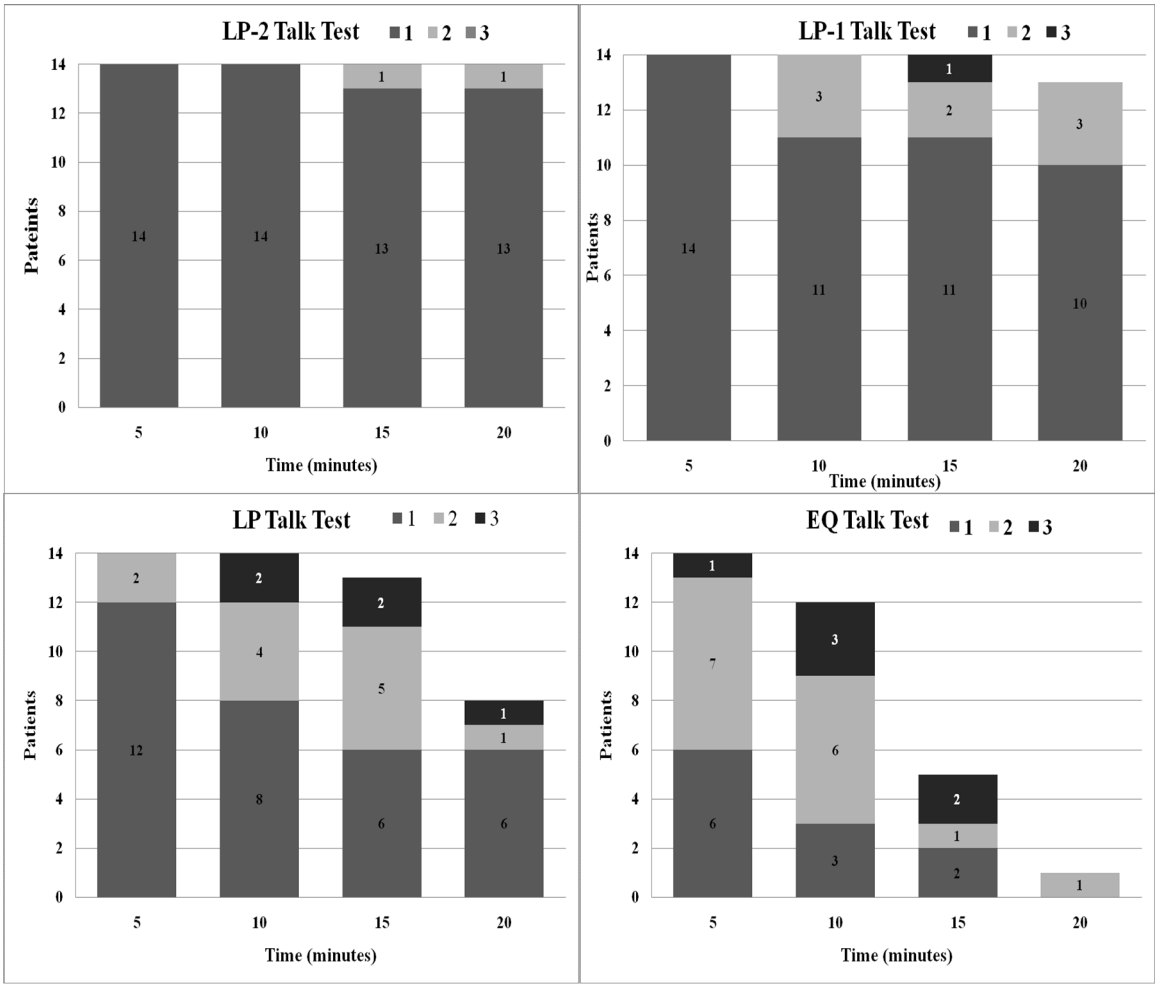

Figure 2. Talk Test responses based on trial intensity.

Heart rate responses and trends for each trial are presented in Figure 3. The longest duration completed by all subjects in all trials was 5 minutes. The mean heart rate(±SD) during this stage was: 91±13.9 bpm for LP-2, 92±13.6 bpm for LP-1, 98±12.7 bpm for LP, and 102±15.1 bpm for the EQ trial.

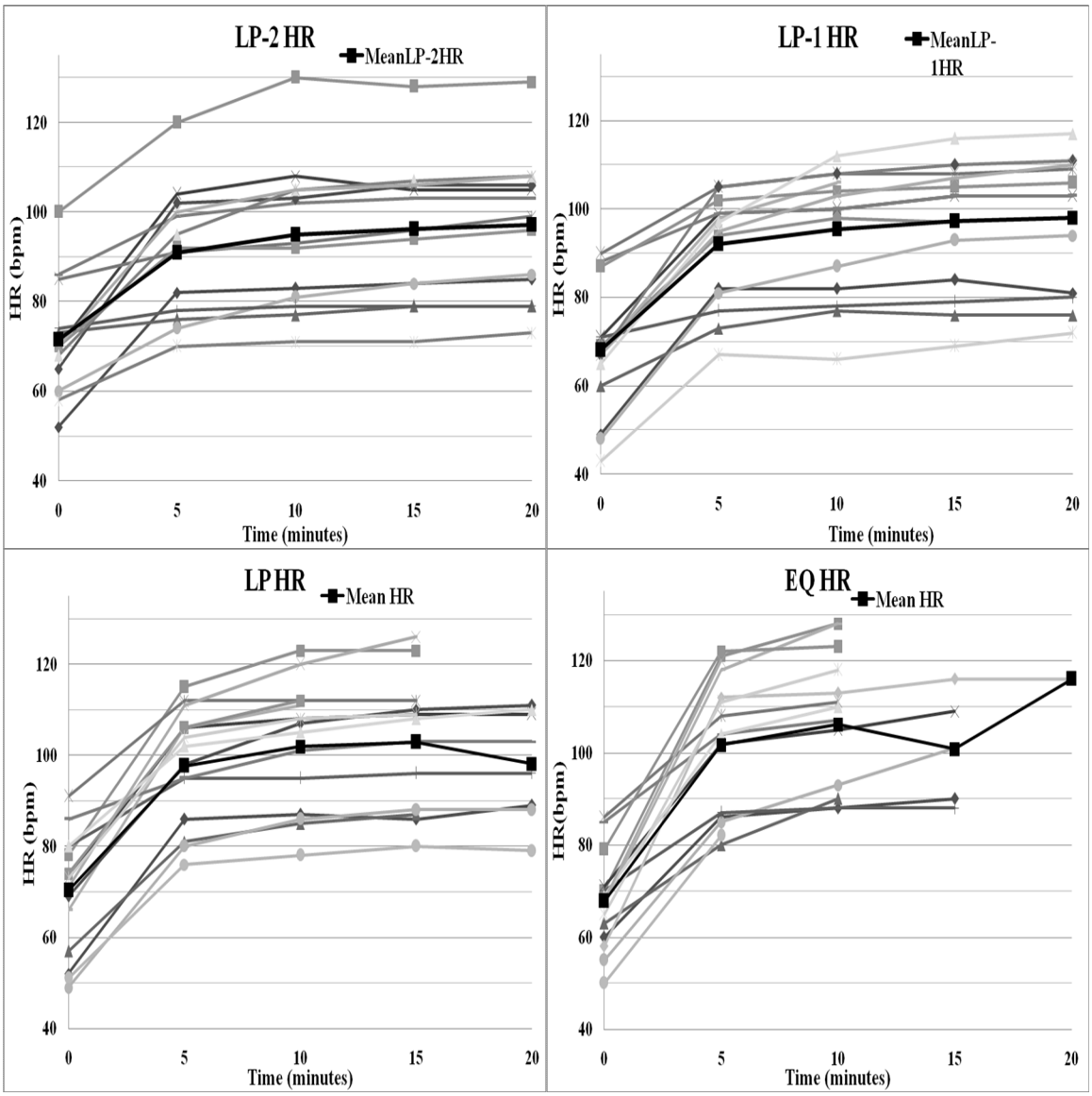

Figure 3. Heart rates responses at all intensities for all subjects.

Figure 4 illustrates the RPE repsonses at all stages of the TT trials. The mean RPE values at the 5-minute measurement periods were: 9.9±1.6 for LP-2, 10.8±1.5 for

LP-1, 11.1±1.1 for LP, and 12.3±1.6 for EQ. Gundersen Lutheran Medical Center(GLMC) consistently tells their patients that they would like them to be working at an RPE of 11-13. It is to be noted that subjects reported reduced speech comfort (as seen in Figure 2.) rather than a high RPE before discontinuing the exercise trial.

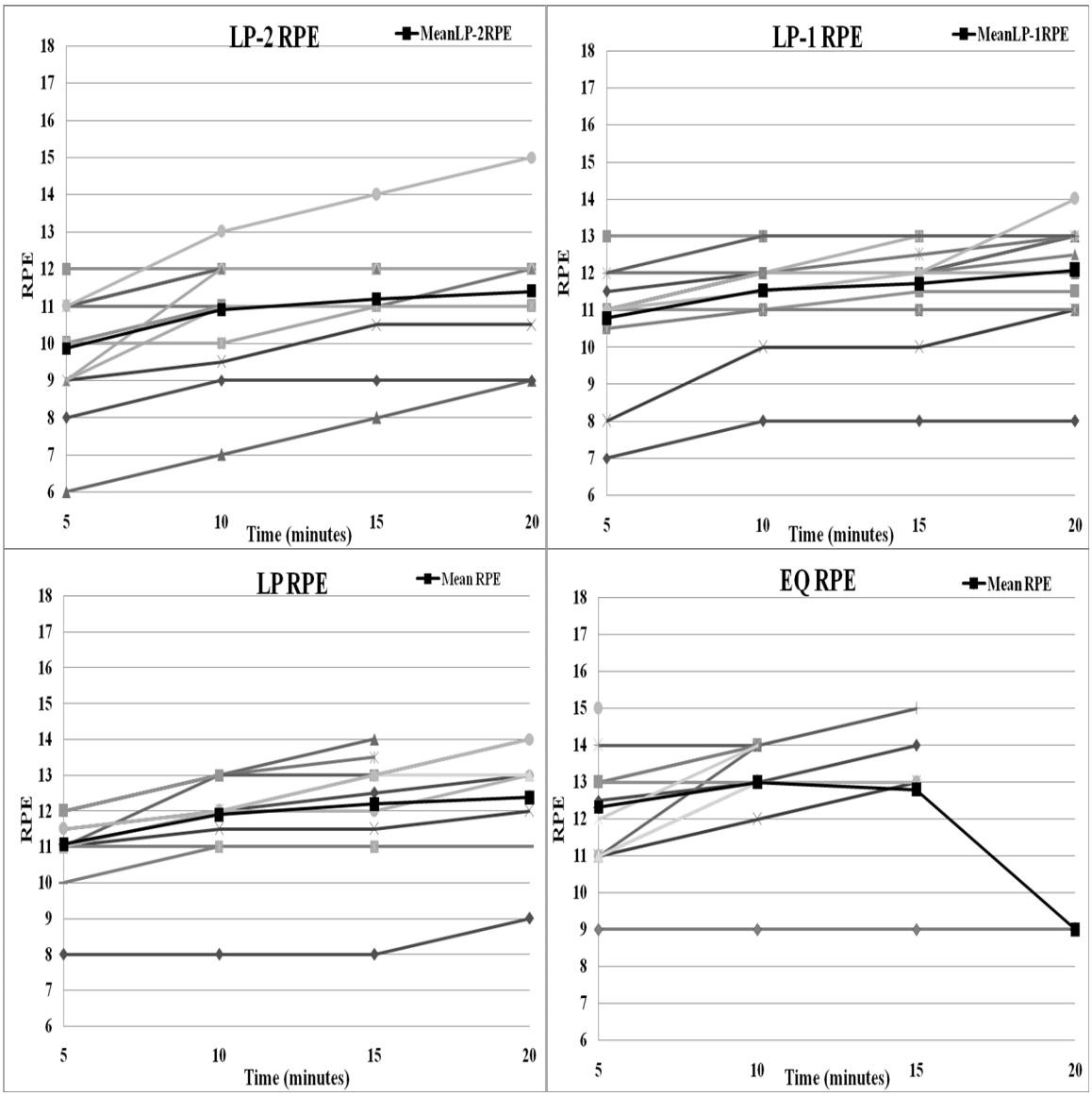

Figure 4. RPE ratings during all four trials.

DISCUSSION

Voelker et al. (2002) have already established that the TT is an appropriate estimate of ventilatory threshold and a suitable means for guiding exercise prescription for cardiac patients. Specifically it was noted that patients unable to speak comfortably during the TT were above VT and beyond ACSM's guidelines for exercise prescription. The purpose of this study was to extend these findings and establish the magnitude of reduction in absolute workload needed to prescribe steady-state training workloads from incremental exercise test results in cardiac rehabilitation patients. The conclusion was based on a patient's ability to complete the 20-minute steady-state exercise bout, speak comfortably, and maintain an adequate RPE, and heart rate response. Accordingly, it seems that the intensity associated with theLP-1 stage of the Talk Test provides the best selection for exercise prescription.

Two previous studies have analyzed the Talk Test's use in translating incremental exercise responses for steady-state exercise. Foster et al. (2009) found that the LP-1 stage was most appropriate for sedentary subjects completing a 20-minute steady-state bout. Both the LP and LP-1 stages of the Talk Test were found to be the appropriate for active adult subjects completing a 40-minute steady-state bout (Jeanes et al., 2010). Similarly, the results of this study demonstrate that the LP-1 stage of the Talk Test allows for almost all patients to complete a 2- minute steady-state exercise bout, with an adequate RPE, and allowing for comfortable speech. Figure 5 presents the mean TT value findings compared to those of Foster et al (2009) and Jeanes (2010). The LP-1's mean TT values

from the current study are remarkably similar to that of Foster et al. (2009) LP-1 and Jeanes et al. (2010) LP and LP-1.

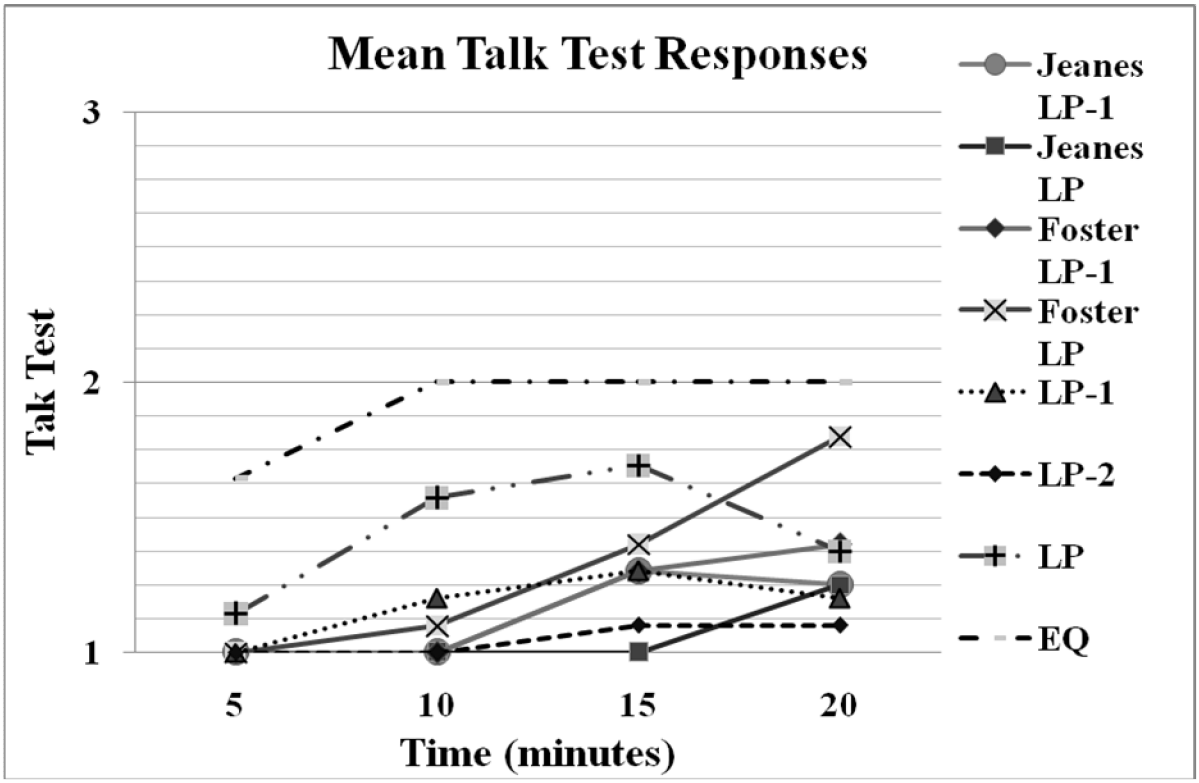

Figure 5. Mean Talk Test Response Comparison.

A common issue throughout the testing of this research was the subject's use of the RPE scale. All of the pateints had completed three weeks of rehabilitation before beginning testing in the current study. During those three weeks the subjects were habitualized to reporting a RPE between an 11 and 13 in accordance to staff goals. Phase III subject's do not regularily use the RPE scale during ther exercise sessions and were unaccustomed to the rating scale. Many of the phase III subjects reported low RPE ratings during the higher intensity trials (LP and EQ) despite an inability to speak comfortably and/or continue the test, though ratings were similar to phase II ratings in LP-1 and LP-2. Figure 6 displays the RPE response differences between phase II and III

patients in all four trials.

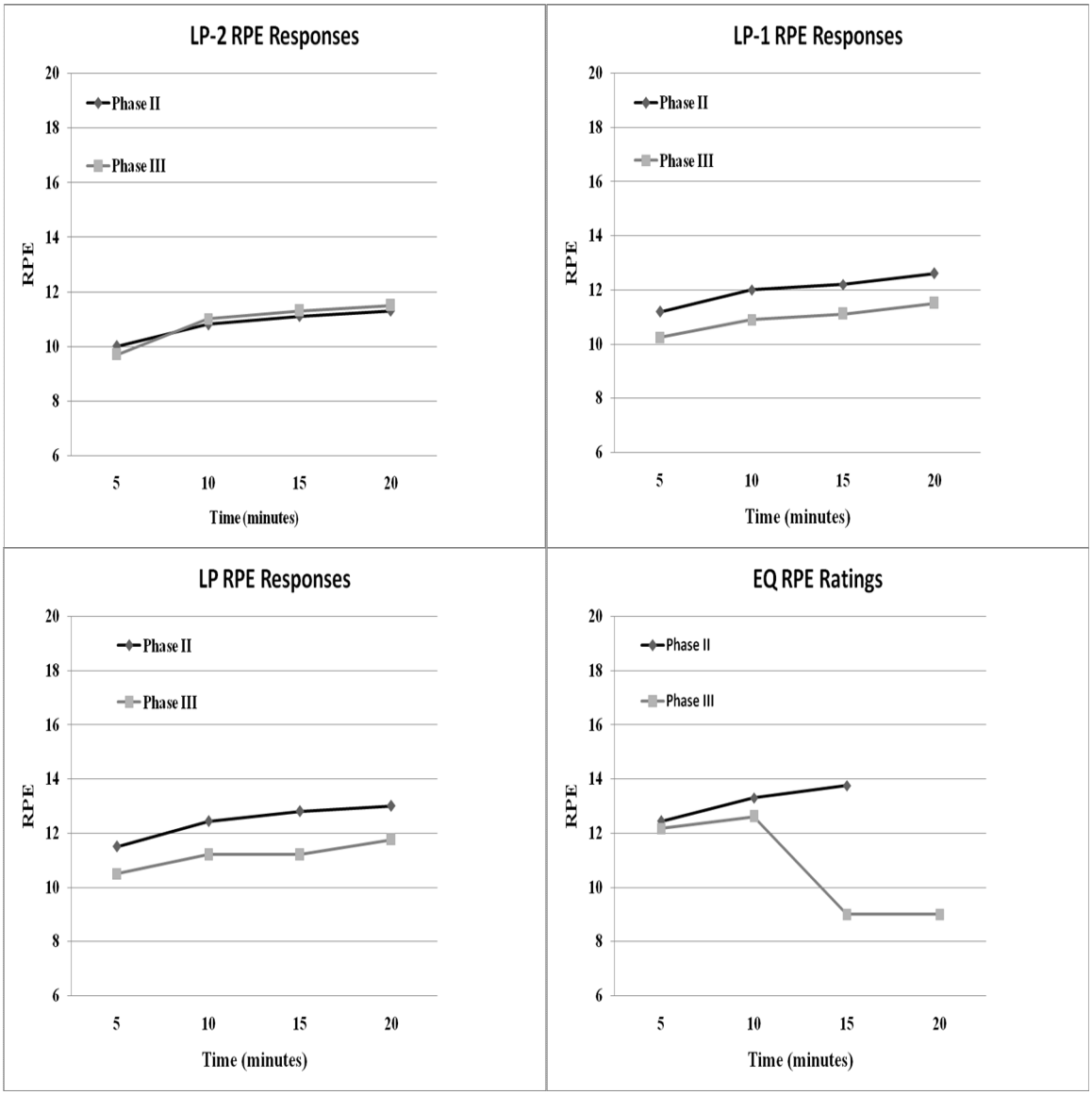

Figure 6. Variation of RPE responses between Phase II and III subjects.

The findings of this study are consistent with previous studies in that when pateints are able to speak comfortably they are at or below their VT. Similarily, the LP-1 stage of the TT is the most appropriate for exercise prescription. It should be noted that in order to ensure comfort in all patients, it may be appropriate to adjust exercise intensity

after 10 minutes of steady-state to the LP-2 stage intensity to allow for speech comfort, appropriate RPE values, and continuation of exercise.

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APPENDIX A

INFORMED CONSENT

Title: Translation of Exercise Test Responses to Exercise Training in a Clinical Population
Principal Investigator: Miranda Menke
Purpose:

- The purpose of this study is to determine how much absolute intensity (treadmill speed and grade) decreases from the intensity during an exercise test to determine a 20-minute training bout that still allows for comfortable speech in cardiac rehabilitation patients.

Procedure:

- The first test required consists of an exercise test on either a treadmill or cycle ergometer during which the workload will increase until you cannot talk comfortably. During this test you will be asked to recite the 'Pledge of Allegiance' every two minutes. Heart rate, blood pressure and you rate of perceived exertion (RPE) will also be measured.
- The subsequent four tests will be at varying exercise intensities established from the first test. They will be performed in random order lasting for 20 minutes. Throughout each test the Talk Test will be measured every 5 minutes by reciting the 'Pledge of Allegiance.' Physiological responses will also me recorded during these trials.
- These tests will all be done during your scheduled time at GLMC as part of your normal rehabilitation program.

Risk:

- The risks incurred during this study are minimal even though you are a cardiac rehabilitation patient.
- If an emergency occurs, persons with CPR and Advanced Cardiac Life Support (ACLS) will be present. All of the tests will be performed in GLMC and you will be monitored continuously.
- The likelihood of serious complications during exercise is very low with this protocol and with the staff and monitoring system present.

Benefit:

- There are no direct benefits to you, except for increased attention and monitoring during their rehabilitation program. However, your participation in this study will

help validate that the Talk Test is a simple and practical way to measure exercise intensity for a clinical population.

Confidentiality:

- The data collected will only be accessible to the principle investigator, faculty advisor, and the cardiac rehabilitation staff at GLMC.
- The results of this study may be published in scientific journals or presented at medical meetings; however, information collected during the study will be coded with numbers and not labeled by personal information.

Compensation:

- Neither Gundersen Clinic, Ltd. nor Gundersen Lutheran Medical Center, Inc. will pay for expenses incurred because of side effects caused by the study procedures unless an employee caused the harm by inappropriate medical care.
- Please contact the Principal Investigator, Miranda Menke, and call 608-782-7300 as well as 1-800-362-9567 in case an injury occurs.

Cost:

- There will be no additional cost for you to pay in order to participate in this study outside of the fees you are already paying to participate in cardiac rehabilitation.

Voluntary Participation and Withdrawal:

- Your participation in this study is voluntary and you may withdraw from the study at anytime and for any reason without penalty. If you choose to not participate in the study you would continue to participate in the cardiac rehabilitation program as prescribed by your physician.

Contact Persons:

- For more information regarding the research and research-related risks or injuries, contact the Principal Investigator, Miranda Menke, at 763-360-4811or her faculty advisor Carl Foster, PhD. at 608- 785-8687. After 5pm, or if you are unable to reach the Principal Investigator, contact the Nurse Advisor at 608-775-4454 or 1-800-858-1050. Tell the Nurse Advisor that you are on a research study and that you may need to be connected to the cardiologist on call. For more information about your rights as a research participant, contact Bernard J. Hammes, PhD, Chair of the Gundersen Lutheran IRB (which is a group of people from the La

Crosse area who review the research to protect your rights), at (608) 782-7300 or 1-800-362-9567.

Statement of Consent:

I have read and understand this consent form. All my questions have been answered. I volunteer to take part in this study. I will receive a signed copy of this consent form.

_____ _____

Signature of Participant Date

_____ _____

Signature of Researcher obtaining consent Date

_____ has read and signed this consent form and told us there are no questions that have not been answered by the researcher. The participant says the consent form is understood and the consent is willingly given. We are writing our names below as witnesses, and we believe the patient understands what is being done and has willingly signed the consent form.

_____ _____

Witness Signature Date

APPENDIX B

TREADMILL PROTOCOL

Balke Treadmill Protocol

Stage	Time (min)	Speed (mph)	Grade (%)	METs Achieved No HRS	HRS
1	1	2.0/2.5/3.0/3.5	0		
	2			2.2/2.5/2.8/3.2	2.1/2.4/2.7/3.0
2	1	2.0/2.5/3.0/3.5	2.5		
	2			2.8/3.3/3.7/4.2	2.7/3.2/3.6/4.1
3	1	2.0/2.5/3.0/3.5	5.0		
	2			3.4/4.0/4.6/5.3	3.3/3.9/4.5/5.1
4	1	2.0/2.5/3.0/3.5	7.5		
	2			4.0/4.8/5.5/5.3	3.9/4.6/5.3/6.1
5	1	2.0/2.5/3.0/3.5	10.0		
	2			4.6/5.5/6.4/7.4	4.4/5.3/6.2/7.1
6	1	2.0/2.5/3.0/3.5	12.5		
	2			5.2/6.3/7.3/8.4	5.0/6.0/6.8/7.7
7	1	2.0/2.5/3.0/3.5	15.0		
	2			5.8/7.0/8.2/9.5	5.6/6.6/7.5/8.5
8	1	2.0/2.5/3.0/3.5	17.5		
	2			6.4/7.8/8.1/10.5	6.1/7.2/8.3/9.4
9	1	2.0/2.5/3.0/3.5	20.0		
	2			7.0/8.5/10.0/11.6	6.5/7.8/9.0/10.2
10	1	2.0/2.5/3.0/3.5	22.5		
	2			7.6/9.3/10.9/12.6	7.0/8.4/9.7/11.0
11	1	2.0/2.5/3.0/3.5	25.0		
	2			8.2/10.0/11.8/13.7	7.5/9.0/10.4/11.9
12	1	2.0/2.5/3.0/3.5	27.5		
	2			8.8/10.7/12.7/14.7	8.0/9.6/11.1/12.8
13	1	2.0/2.5/3.0/3.5	30.0		
	2			9.4/11.4/13.6/15.7	8.5/10.2/11.8/13.7

Reference: C Foster et al. Med Sci Sports Exerc 28: 752, 1996
T McConnell et al. J Card Rehabil 11 :225, 1991

APPENDIX C

CYCLE ERGOMETER PROTOCOL

Cycle Ergometer Protocol

Stage	Time (min)	Watts	VO2 (ml/min)
1	1 2	15	485.5
2	1 2	30	667
3	1 2	45	851
4	1 2	60	1034
5	1 2	75	1218
6	1 2	90	1402
7	1 2	105	1585
8	1 2	120	1769
9	1 2	135	1952
10	1 2	150	2136

APPENDIX D

RATE OF PERCEIVED EXERTION (RPE) SCALE

Borg RPE Scale:

6	
7	Very, very light
8	
9	Very light
10	
11	Fairly light
12	
13	Somewhat hard
14	
15	Hard
16	
17	Very Hard
18	
19	Very, very hard
20	Maximal

APPENDIX E

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 F

REVIEW OF LITERATURE

Introduction

Exercising at an appropriate intensity is crucial for any population. One of the most popular ways of prescribing exercise intensity is by using results from a maximal exercise test. One of the main concerns when using exercise tests for exercise prescription is that exercise tests are incremental protocols while exercise training is steady-state. Due to issues, such as cardiac drift, the steady-state workout intensity needed to reach a target heart rate has been shown to be less than that during an incremental exercise test. Foster et al. (1986) studied to find the reduction in workload between the incremental exercise test workload intensity and steady-state exercise training intensity to reach a target heart rate. His study tested cardiac rehab patients and participants in exercise programs on either a treadmill or a cycle ergometer. It was found that on both the treadmill and cycle ergometer there is a linear relationship between training pace or power output and the graded exercise test's (GXT's) equivalent heart rate time. This means a reduction rate can used to prescribe an exercise training intensity from GXT results. Is this reduction rate the same for all modes of exercise? A study was conducted to determine the "translation" equation to translate exercise testing results to exercise training on an arm-leg ergometer. This study observed healthy subjects who completed a maximal test as well as three 20-minute trials at selected intensities of easy, medium, and hard. The results showed that the reduction from exercise testing to exercise training for the arm-leg ergometer is less than that of the reduction rate previously found for the arm ergometer (Foster et al., 1991). Though the reduction rates were different they both were still close to the generalized prediction made that the reduction rate will be about 25% less than that of the GXT equivalent.

Results from GXT's are most often used to prescribe exercise intensities for exercise equipment that can maintain a constant workload. However, many people want guidelines for recreational activities where a constant workload is not kept. Foster, C & Thompson, N (1991) prepared a study to determine if using the already published Metabolic Equivalent of Task (METS) for some recreational activities could predict appropriate responses in participants. They selected eighteen active individuals to perform various recreational activities. Using a nomogram, each recreational activity was predicted to be either too easy, adequate, or too hard. The results from this study showed that the majority of the activities were easier than predicted. Thus recreational activity may not play as big of a role in "conventional aerobic training effects". Though the findings may pose a problem for populations looking to improve aerobic capacity, the results are beneficial to new exercisers or patients worried about overexertion and potential catastrophic events.

GXT results have been shown to be a reliable means of prescribing exercise intensity. This is why the most common used means of prescribing exercise intensity is through measurements associated with GXTs. ACSM (2010) currently prescribes 40-80% of HRR, VO_2R, or VO_2Peak for the apparently healthy adult population.

Talk Test

Though the GXT has been shown to be a reliable means of prescribing exercise training intensity, a GXT may not be appropriate for everyone. Cardiac rehabilitation patients, for instance, are too high risk to perform a GXT without the presence of a physician. Foster et al. (2008) stated that the risk for complications is 20% higher during an exercise test compared to exercise training in cardiac patients. Additionally, handrail

support has been shown to affect exercise test results, so any patient needing the assistance of the handrails would not be appropriate for a maximal exercise test (Berling et al., 2006).

A possible alternative to the maximal exercise test is the sub-maximal Talk Test (TT), which is a subjective and incremental exercise test based on the ability to speak during exercise. The Talk Test began as advice by Professor John Grayson in 1939 when he advised English mountaineers to "climb no faster than you can talk" (Goode, R, 2008). The premise behind the TT is that the ability to speak comfortably is a reflection of ventilatory control. Accordingly, as your intensity increases your ventilatory control and thus ability to speak comfortably will decrease. In a TT subjects perform exercise and are asked to recite a passage or paragraph followed by answering the question "Can you speak comfortably?" The subject can respond yes, anything other than "yes", and no. In the TT, stages in which the subject answers "yes" are positive stages, the first stage in which they answer anything other than "yes" is considered the equivocal stage (EQ), and "no" is considered a negative stage.

Because of the relationship between the Talk Test and ventilatory control, a comparison of the Talk Test and ventilatory threshold (VT) would be an appropriate way of measuring the validity of the Talk Test. Dehart-Beverly et al. (2000) performed a study to determine the relationship between the Talk Test and VT in healthy adults. In this study 28 healthy subjects completed two maximal tests. This first test was completed using a gas exchange machine to measure VO^2 while the second test was done without this machine and used the TT protocol (having the subjects complete the "rainbow passage" at the end of each stage until they could no longer talk comfortably). The

results of this study showed no significant differences in the variable between the EQ stage of the TT and VT while showing significant differences between the first negative stage and VT. This study showed that if you can talk comfortably you are below VT, if you are unsure if you can talk comfortably you are at VT, and being unable to talk means you are past VT. In continuation with the previous study, Shafer et al. (2000) did a study to find the relationship between the TT and VT in the sedentary population. Ten subjects completed three randomized exercise tests including one measuring gas exchange while the other two just completed the TT reciting the longer "rainbow passage" and then the shorter "Pledge of Allegiance." The study found that at the last positive stage (LP) of the Rainbow Passage test the VO_2, SPE and other variables were above that of VT. The Pledge of Allegiance showed similar results. The findings for this study were that if the subject was starting to become uncomfortable talking they were past VT unlike Dehart's where they were at or close to VT. Recalde et al. (2002) expanded upon this and decided to test the Talk Test on a new population, highly-trained adults. Sixteen well-trained subjects participated in three trials the first being a practice session followed by a VO_2max test and a TT. The study found that the TT's LP, EQ, and negative stage all correlated to the VO_2 at VT. The most closely correlated to the VO_2 at VT was the EQ stage of the TT. This supports previous studies' findings that TT stages below EQ are below VT, EQ is close to being at VT, and any intensity beyond negative stage is beyond VT.

As mentioned before, cardiac patients are too high risk for GXTs without the presence of a physician. The TT therefore, poses a valuable alternative as a means to prescribe exercise. Voelker et al (2002) performed a study to determine if the TT is

appropriate for intensity prescription in cardiac patients. Ten cardiac rehab patients performed two incremental and maximal exercise tests, the first measuring their respiratory gas exchange and RPE and the second using the TT. This study showed that a patient beyond EQ of the TT will be beyond their VT. The HRs of the TT trial correlated with the HRs of the first trial and were within ACSM's guidelines.

As Foster et al. (1991) tested the consistency of GXT results translation to exercise training intensity on different exercise equipment; Persigner et al. (2004) performed a study to test the consistency of the TT on different modes of exercise. Sixteen healthy and active subjects performed four exercise tests (two on a treadmill, two on a cycle ergometer). The results showed that the VT for the cycle ergometer and treadmill were similar by means of the Talk Test. The study also supported the notion that the LP and EQ stages are within intensity guidelines while negative stage exceeds the recommendation.

In order to further test the consistency of the TT, Rotstein. (2004) performed a study to look at TT responses and its responses to changes in HR, O_2 consumption, anaerobic threshold, and ventilation. Fourteen healthy subjects completed a resting pulmonary assessment and an incremental treadmill exercise test. The TT was performed for the first half of the treadmill test. The subjects would continuously read a passage and rate the speech difficulty based on a scale made for this study. Once they could no longer comfortably speak they continued the test without speech until exhaustion. The study found that there is a relationship between exercise intensity and our perceived speech difficulty most likely due to the relationship between speech control and VT. Another finding was that the range of perceived speech difficulty was very wide for a

given VO_2. Having such a wide range of ratings for a single VO_2 decreases the effectiveness of using the TT as a means of prescribing exercise workloads. However, as aforementioned this study used a protocol of the TT having the subjects continuously speak while all of the previous studies have a intermittent passages read at the end of exercise stages. Foster et al. (2008) also wanted to perform a study testing the consistency of the TT. Their study changed the exercise protocol of a trial or manipulated VT in order to observe TT's response. Subjects performed four trials (decreased VT, increased VT, and two exercise intensity variations above and below VT.) The study showed that the TT matches variations made to VT, although with greater error if intensity is pushed beyond VT.

TT and Clinical Populations

Since cardiac rehab patients are high risk for catastrophic events it is important to test the safety and consistency of the TT for them. Voelker et al. (2002) showed us that the TT correlates to VT in cardiac rehabilitation patients. It has also been shown that VT is below ischemic threshold. Cannon et al. (2004) performed a study to determine if the TT is an appropriate method for avoiding ischemia. The study took 19 patients with abnormalities related to ischemia and had them perform an exercise TT while recording measurements for ischemia, BP and HR. This study showed that generally the LP of the TT preceded the onset of ischemia.

Brawner et al. (2006) focused on studying the ability to use the Talk Test to prescribe exercise in patients with Coronary Artery Disease (CAD). Twenty-four patients with CAD completed one maximal and two sub-maximal exercise tests. The two sub-maximal tests were both TTs with one being completed on a treadmill and the other

on an indoor track. The protocol on the treadmill followed protocol stages of the maximal test while the track TT protocol was set for the subjects to walk/jog at the fastest pace that still allowed them to talk comfortably. The results of this study were that at the LP on the treadmill 48% of the patients were above VT and at the EQ of the TT 89% of the subjects were above VT. During the self paced track TT 62% of the subjects were above VT and in general there were no significant differences between the two TT protocols. This study supports past studies in finding that when a person can still talk comfortably they are at or below VT while if they cannot speak comfortably they are above VT. This study also helped to further support the validity and consistency of the TT between different protocols.

Translation of the TT

Just as with a maximal test, there is a need to translate results from the incremental Talk Test to steady-state exercise intensity. Foster et al. (2009) studied the reduction needed from the Talk Test results to exercise training intensity in sedentary adults. This study found that the stage preceding the last positive (LP-1) and LP resulted in stable HR's while EQ caused a progressive HR drift. Similarly, LP-1 and LP resulted in appropriate RPE's while EQ caused high RPE's and fatigue. The main conclusion from this is that in order to speak comfortably for a 20-minute bout we must decrease from the dimensions of EQ. Jeanes et al. (2010) did a similar study with active adults. The study took physically active participants and had them perform six tests (max, max with talk test, steady state LP, steady state LP-1, steady state EQ, and max with talk test). Results showed that heart rates and RPE's were appropriate for LP and LP-1 trials but exceed appropriate levels in EQ level trials.

Summary

The Talk Test has been shown as consistently correlating with ventilatory threshold, responding appropriately to changes in ventilatory threshold, and responding appropriately on different modes of exercise in a variety of populations. It also has been shown as an appropriate means of translating incremental exercise test results to steady-state exercise training workloads in sedentary and active adults. What has yet to be seen is the translation of incremental results to steady-state workloads in a clinical population.

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