

UNIVERSITY OF WISCONSIN-LA CROSSE

Graduate Studies

CAN CARDIAC PATIENTS USE ONLY THE TALK TEST TO SELF-MONITOR  
APPROPRIATE EXERCISE INTENSITY LEVELS?

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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College of Science and Health  
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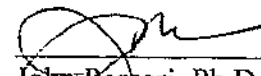
By Katherine J. Doro

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


The candidate has completed the oral defense of the thesis.

  
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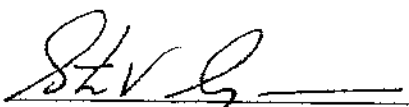
  
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## ABSTRACT

Doro, K.J. Can cardiac patients use only the talk test to self-monitor appropriate exercise intensity levels? MS in Clinical Exercise Physiology, December 2015, 56pp. (C. Foster)

The purpose of this study was to determine if cardiac patients could use only the talk test to monitor exercise intensity and stay within appropriate intensity ranges. This study tested 16 phase II cardiac rehabilitation patients and had them complete three treadmill tests. The first was a submaximal exercise test used to determine ventilatory threshold stages. The second test was a 20-minute exercise bout where patients adjusted their intensity based on their talk test responses. The third test was a maximal exercise test used to determine maximal heart rate. The values from the 20 minute exercise bout and maximal test were compared. Subjects were within the ACSM intensity guidelines for percent heart rate reserve, steady state MET levels/percent of maximal MET, and rate of perceived exertion when compared to maximal values. This study supports the notion that cardiac patients can use only the talk test to self-monitor exercise intensity levels and remain in appropriate intensity ranges.

## ACKNOWLEDGEMENTS

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Thank you to my family and friends who have supported me continuously throughout this endeavor. This project was, at times, challenging and I’m not sure I would have come through it as well as I did without the unyielding support and comfort from those closest to me. I would like to specially thank my mom and dad for always being just a phone call away and never getting tired of hearing about my thesis project. I also owe my brother Kevin big time for helping me maneuver through excel so that I wouldn’t pull out all of my hair.

Thank you to Carl and my thesis committee for your endless editing and eye opening wisdom.

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## INTRODUCTION

When people begin to exercise, the basis for the exercise program can be defined by American College of Sports Medicine (ACSM) guidelines for exercise (Pescatello, Arena, Riebe, Thompson, 2014). The guidelines are given in a prescription form as Frequency, Intensity, Time, Type, Volume, and Progression also known as the FITT-VP principle. For most individuals, the FITT-VP principle is intrinsically easy to understand and apply, except for the intensity of exercise. Intensity can be expressed in many forms including: % maximal Oxygen Consumption ( $\%VO_{2max}$ ), % Oxygen Consumption Reserve ( $\%VO_{2R}$ ), % Heart Rate Max ( $HR_{max}$ ), % Heart Rate Reserve ( $\%HRR$ ), % Metabolic Equivalents (% METs), as a measure of Ventilatory Threshold (VT), and as the Rating of Perceived Exertion (RPE) (Pescatello et al., 2014). Another less commonly used measure of intensity is known as the Talk Test (TT), a subjective measure of intensity that is based on the ventilatory threshold (Dehart-Beverly, Foster, Porcari, Fater, & Mikat, 2000).

The TT is based on the fact that in order to speak, air has to be expelled from the lungs to vibrate the vocal chords. Since speech requires a suppression of breathing frequency, the natural increase in breathing frequency at the point of the VT often makes speech less comfortable. The idea of the TT stems from Professor Grayson's advice, in 1939, to the British mountaineers of "climb no faster than you can talk". From here, the TT has evolved from observing the impact of speech on ventilation (Doust & Patrick, 1981) to guide for exercise intensity prescription and alternative form of exercise testing



(Foster, Porcari, Gibson, Wright, Greany, Talati & Recalde, 2009; Goode, Mertens, Shaiman, & Mertens, 1998).

The TT has been validated for numerous populations (young adult, athlete, sedentary, elite athlete) as well as in cardiac populations (ischemic heart disease, coronary artery disease (CAD), coronary artery bypass graft (CABG) patients and percutaneous coronary intervention (PCI) patients) (Brawner et al., 2006; Dehart-Beverley et al., 2000; Foster et al., 2009; Nielsen et al., 2014; Petersen, Maribo, Hjortdal, & Lausten, 2014; Recalde, Foster, Skemp-Arlt, Fater, Neese, Dodge, & Porcari, 2002; Rodriguez-Marroyo, Villa, Garcia-Lopez, & Foster, 2013; Voelker et al., 2002). In addition to being reliable for a variety of subjects (Ballweg et al., 2013), the TT has also been validated in the treadmill and the cycle ergometer, the most common modalities for exercise stress testing (Brawner et al., 2006; Persinger, Foster, Gibson, Fater, & Porcari, 2004). The TT uses a standard speech provoking stimulus, commonly the “Pledge of Allegiance” or the “Rainbow Passage”, to test the subject’s ability to speak comfortably during exercise. Based on the subject’s response, the TT can determine the subject’s exercise intensity in relation to the ventilatory threshold. Since the TT is a subjective measure of intensity, matched with a physiological marker of intensity, it is adaptable each time a person exercises and does not require heart rate (HR) as a measure of intensity so the TT is effective for individuals who may be on medications impacting the HR response to exercise.

Recent research has explored the potential for the TT to be used as a submaximal, incremental exercise test, with results of that test to prescribe steady-state exercise in both normal populations and cardiac patients (Lyon, Menke, Foster, Porcari, Gibson, &

Bubbers, 2014; Woltman et al., 2015). The purpose of the Lyon et al. (2014) study was to determine if cardiac patients could complete 20 minutes of steady-state exercise at certain levels of intensity, identified by the equivocal stage of the TT during incremental exercise. They found that patients could complete the stages if they were at intensities below the LP stage of the TT. Woltman et al. (2015) examined the physiological impact of “clamping” the TT at certain intensity levels, forcing well-trained subjects to adjust their intensity to stay in the appropriate TT range. Subjects were able to adjust their intensity to stay in the TT ranges and, in fact, reached steady-state exercise in some of the stages (Woltman et al., 2015). These two studies suggest the next step in the evolution and application of the TT, as well as the purpose of this study. The purpose of the present study was to determine if cardiac patients could use just the Talk Test to adjust their intensity levels and stay in appropriate intensity ranges throughout 20 minutes of exercise session?” We hypothesized that cardiac patients would be able to maintain steady state exercise within appropriate intensity ranges using only the Talk Test to monitor their intensity.

## **METHODS**

Eighteen cardiac patients, who were within a week or so of graduating from a Phase II rehabilitation program, were recruited from Gundersen Medical Center. Testing took place during a normal cardiac rehabilitation class and all data collection was completed within a week of the maximal stress test. Characteristics of the cardiac patients as well as their diagnoses and medications can be seen in Figure 1-3. All subjects provided written informed consent prior to testing and confirmed they took all their medications prior to testing. The protocol was approved by the Institutional Review Boards of both the University of Wisconsin-La Crosse and Gundersen Medical Center. No changes in medications occurred for any subject throughout the week of their testing. Subjects performed a submaximal incremental walking treadmill test, on a standard calibrated treadmill, while reciting three verses of “Twinkle Twinkle Little Star” at the end of every three minute stage. HR was recorded through ECG telemetry monitoring used in all rehab classes. After reciting the passage, the participant then answered the question, “Can you speak comfortably” with a “yes” (positive TT response), “yes, but” (equivocal TT response), or “no” (negative TT response). The exercise test ended when the participant responded with “no”. The participant’s heart rate and RPE were monitored at the end of every stage of the test.

On a subsequent day, the subject performed a 20-minute training bout on the treadmill. The beginning intensity was at the stage known as the “last positive” (LP) or

the last stage the subject said “yes” during the submaximal incremental test completed on the previous testing day. At the end of every two minutes, the subject recited Twinkle, Twinkle Little Star. Then based on the subjects’ answers to the question “can you speak comfortably”, the grade (speed was constant) of the treadmill was adjusted. If the answer was “yes”, the grade of the treadmill increased, if the answer was “equivocal” or “no”, the grade decreased. This manipulation continued until the highest sustainable grade that allowed comfortable speech was identified. In practical terms this usually meant that the subject started with comfortable speech, lost the ability to speak comfortably, then regained (and sustained) the ability to speak comfortably for the duration of the exercise session. This way we were confident that the subject was exercising at the highest possible intensity consistent with comfortable speech. This intensity was then compared with conventional %HRR, %METs, and RPE goals during training. Lastly, on a separate day the patient performed a maximal incremental stress test (part of normal discharge procedures from the Gundersen Medical Center rehabilitation program) to allow determination of maximal METs and HR. These values allowed the MET load and HR at the highest workload with comfortable speech during the steady state bout to be put into context relative to the ACSM guidelines (Pescatello et al., 2014). Throughout all of the tests the subjects were instructed not to hold onto the treadmill handrails.

Table 1. Descriptive statistics of the subjects

	Male (n=15)	Female (n=1)
Age (yr)	64.6±10.4	69.0±0.0
Height (cm)	175.3±9.4	168.9±0.0
Weight (kg)	104.4±26.3	75.8±0.0
Max METs	7.2±1.8	6.8±0.0
Max HR (bpm)	127±15.6	141±0.0

Values presented represent mean ± standard deviation.

Table 2. Descriptive statistics of cardiac diagnoses (subjects)

	Male (n=15)	Female (n=1)
MI	3	0
PCI	8	0
CABG	5	1
Aortic Valve Replacement	2	0
Ascending Aortic Replacement	1	0
Angina	1	0
CHF	1	0
PAD	1	0

Values presented represent total from all subjects.

Table 3. Descriptive statistics of medications (subjects)

	Male (n=15)	Female (n=1)
Beta Blockers	15	1
ACE Inhibitor/ARBs	9	1
Statin	15	1
Antiplatelet	15	1
Diabetic	4	1
Nitrate	1	0

Values presented represents total from all subjects.

### Statistical Analysis

Aside from the mean and standard deviation for the various outcome measures, no other statistical analyses were run. All results from this study were observational.

## RESULTS

The steady-state MET level, percent heart rate reserve (% HRR), and RPE at the highest workload allowing comfortable speech were observed to see if they fell within the ACSM recommended intensity ranges. Subjects started at a low intensity and then adjusted grade, while keeping speed constant (Figure 1), to change intensity based solely on their TT response. TT responses are presented in Figure 2. When subjects could speak comfortably, intensity was increased; when speech was unequivocally uncomfortable, intensity was decreased. This process continued until subjects found the highest grade that allowed for comfortable speech. Most subjects achieved steady state by minute 15 of the steady-state bout. The heavy black line represents the average for the group, and the thin lines represent individual responses.

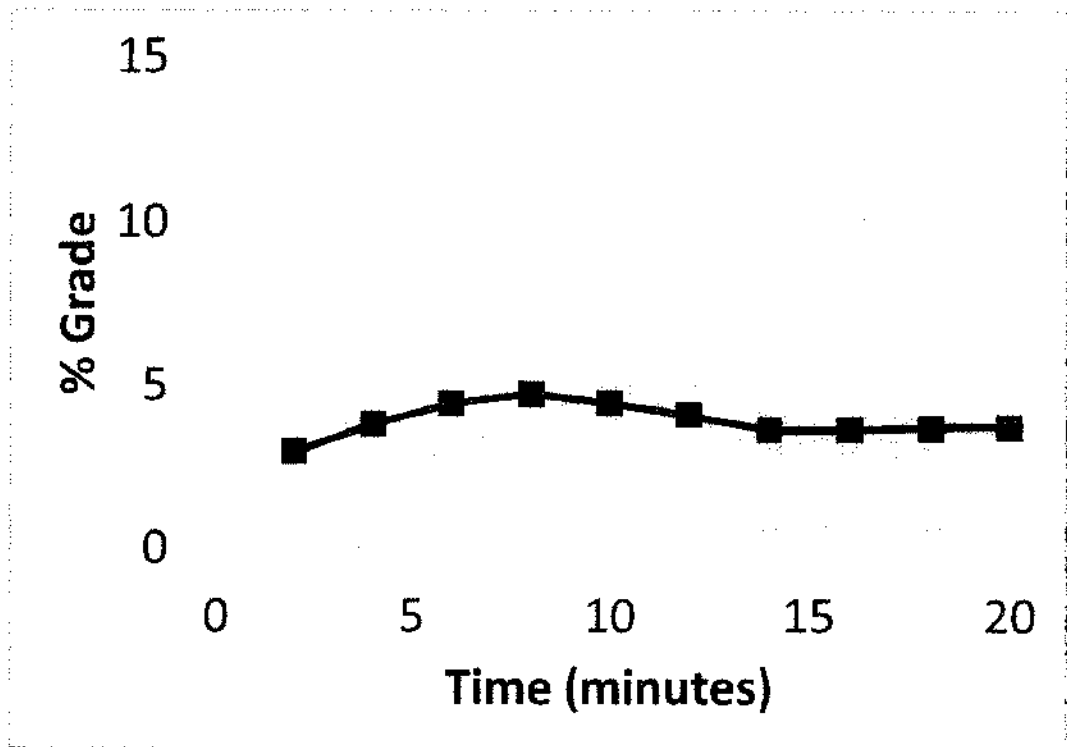


Figure 1. Change in treadmill grade throughout the 20-minute exercise bout.

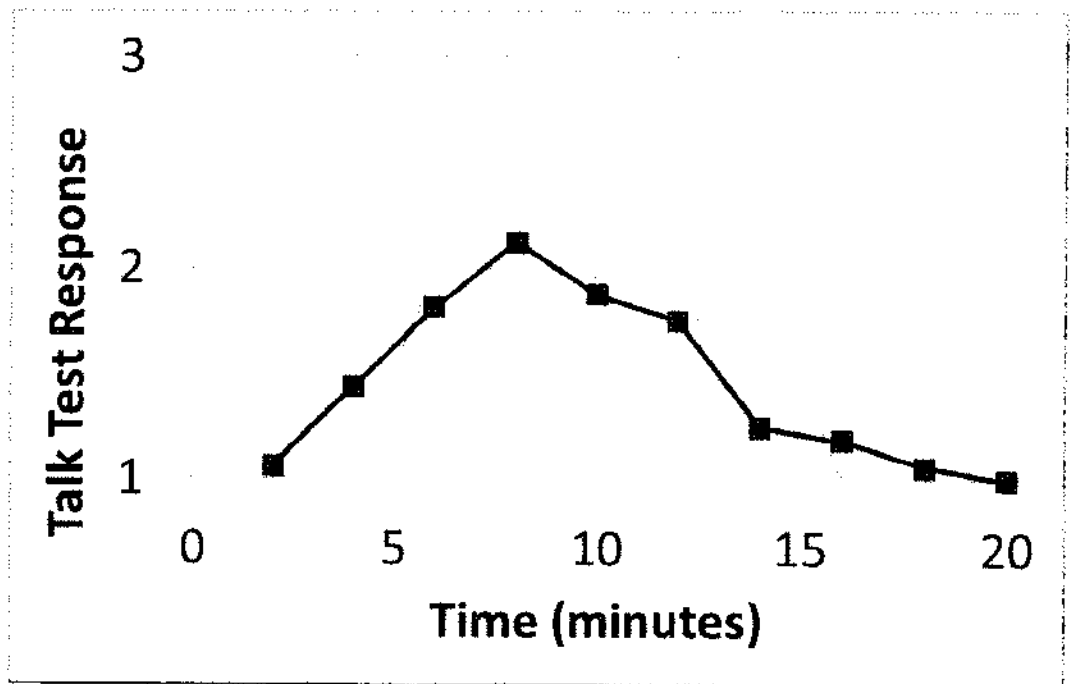


Figure 2. Talk test response throughout the 20-minute exercise bout. (1= speech is comfortable; 2 = speech is getting harder; 3 = speech is not comfortable)



Throughout the 20-minute exercise bout, both HR and RPE were recorded at the end of every two-minute stage. Steady-state HR and RPE values were achieved toward the end of the 20-minute exercise bout as seen in Figure 3 and Figure 4. The gray box represents the ACSM recommended RPE guidelines of 11-13 on the Borg scale. The average of all the participants fell within the ACSM guidelines for the majority of the exercise bout.

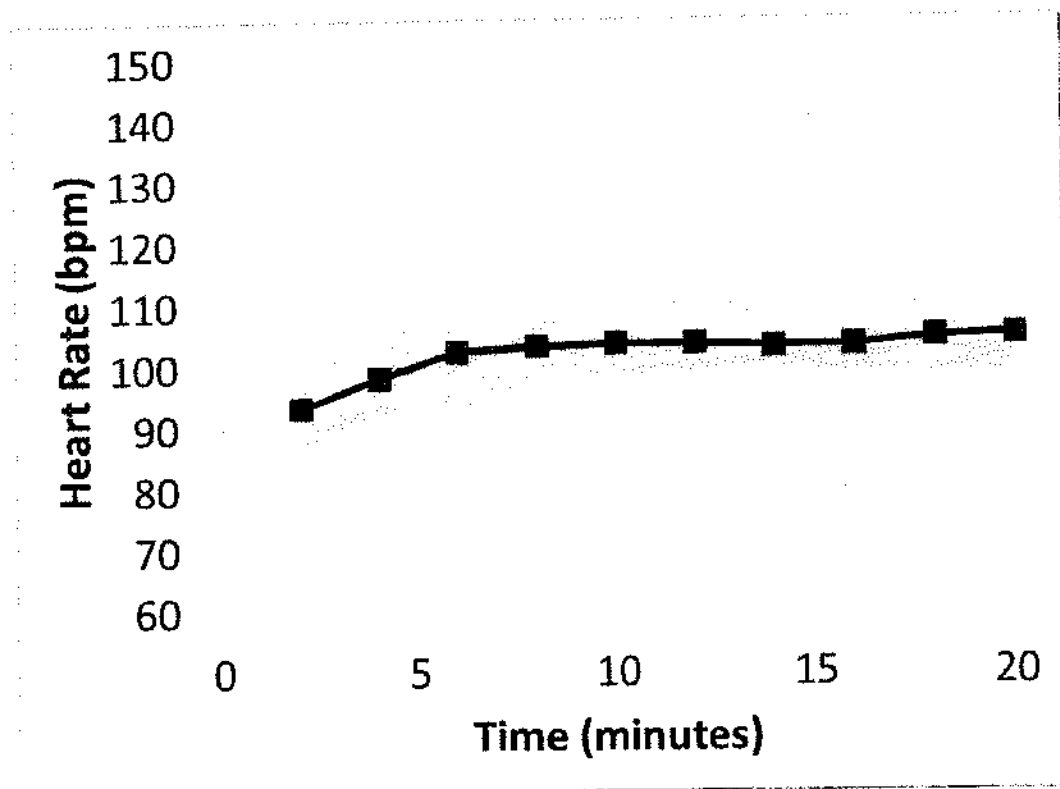


Figure 3. Change in heart rate during the 20-minute exercise bout.

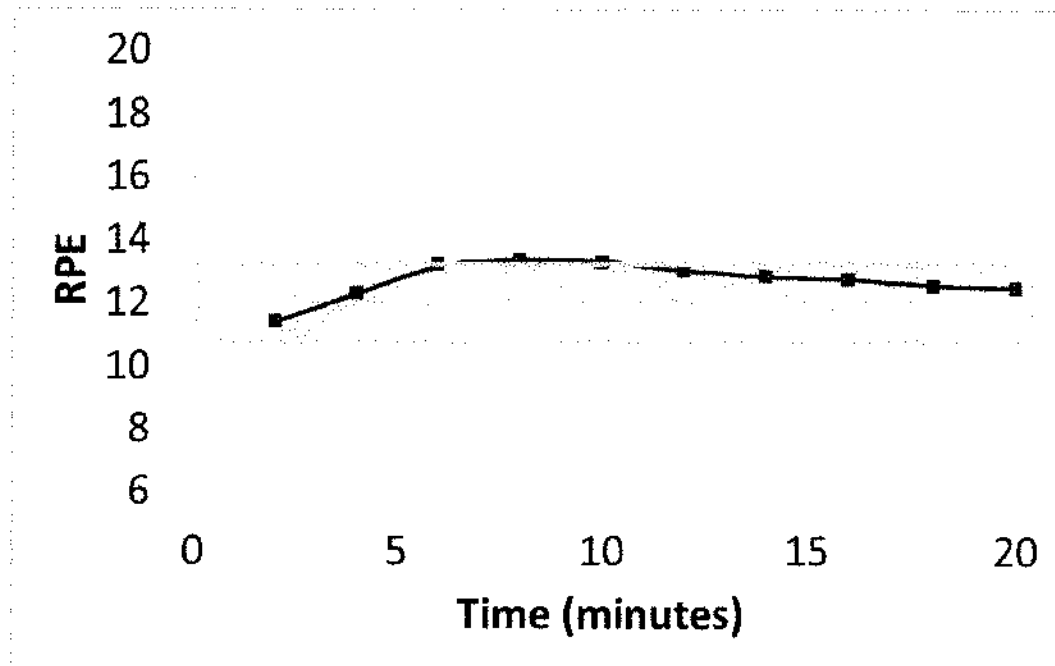


Figure 4. Change in RPE during the 20-minute exercise bout.

Exercise intensity was also represented through calculation of METs at each stage (steady state METs), percent of maximal METs, and percent of HRR at each stage. Figures 5-7 have gray boxes showing the ACSM intensity recommendations for each measure of intensity. In all of the figures, the averages of the subjects fell within the ACSM guidelines for majority of the exercise bout.

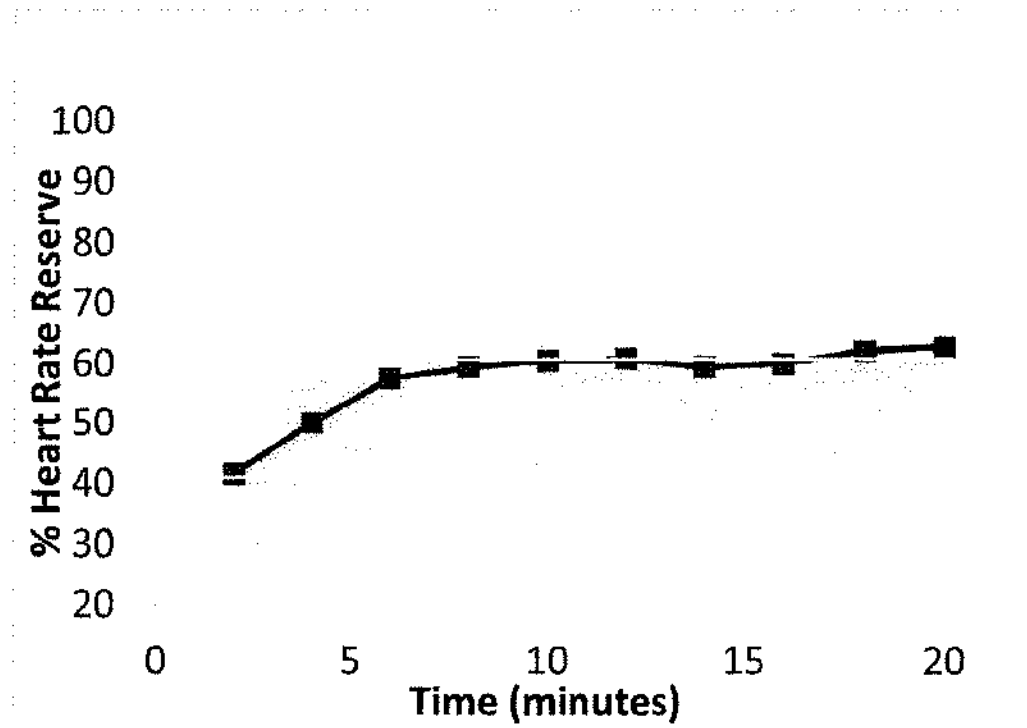


Figure 5. Percent of Heart Rate Reserve throughout the 20-minute exercise bout.

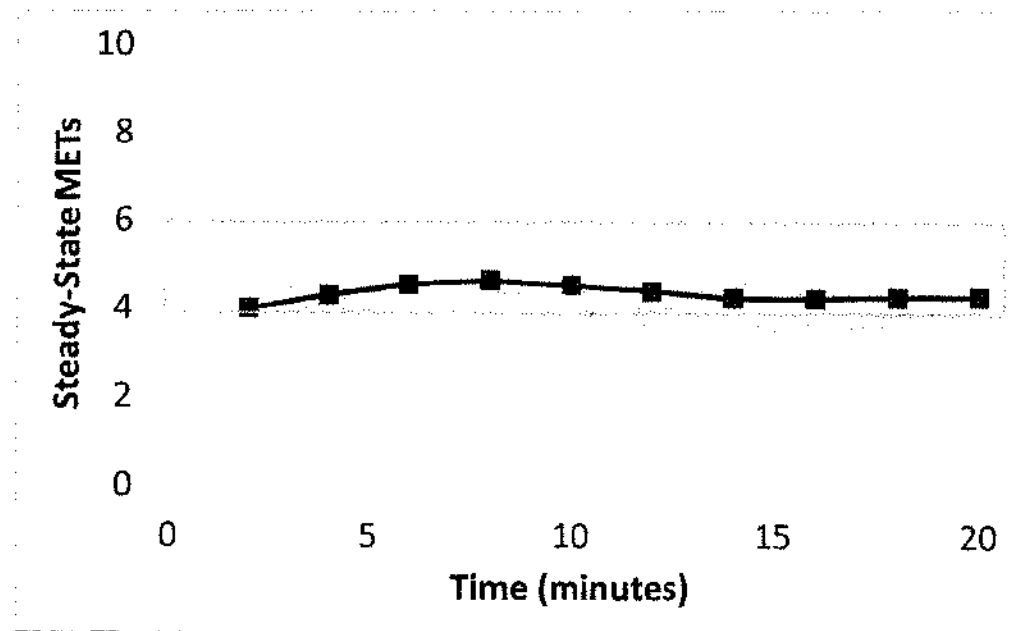


Figure 6. Steady-State METs throughout the 20-minute exercise bout.

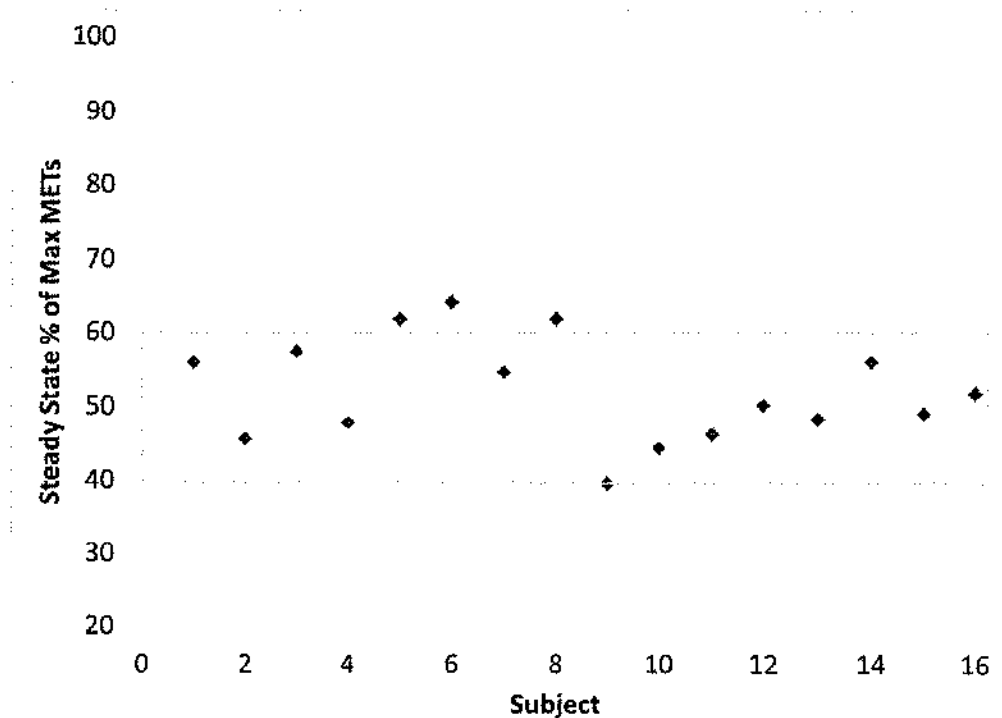


Figure 7. Percent of Maximal METs when optimal intensity level was achieved during the 20 minute exercise bout based solely on the TT.

The average percent of maximal METs per stage of the 20-minute exercise bout were calculated (Figure 8). Steady-state METs and % maximal METs were determined and compared. (Figure 9). The METs were calculated using the ACSM walking equation.  $[(3.5 + (0.1 * \text{speed}) + (1.8 * \text{speed} * \text{grade}))]$  Maximal METs were estimated based on how many minutes of the last stage a subject completed (Foster et al., 1996). Steady-state METs were achieved when a subject remained at the same intensity level for more than one stage in a row.

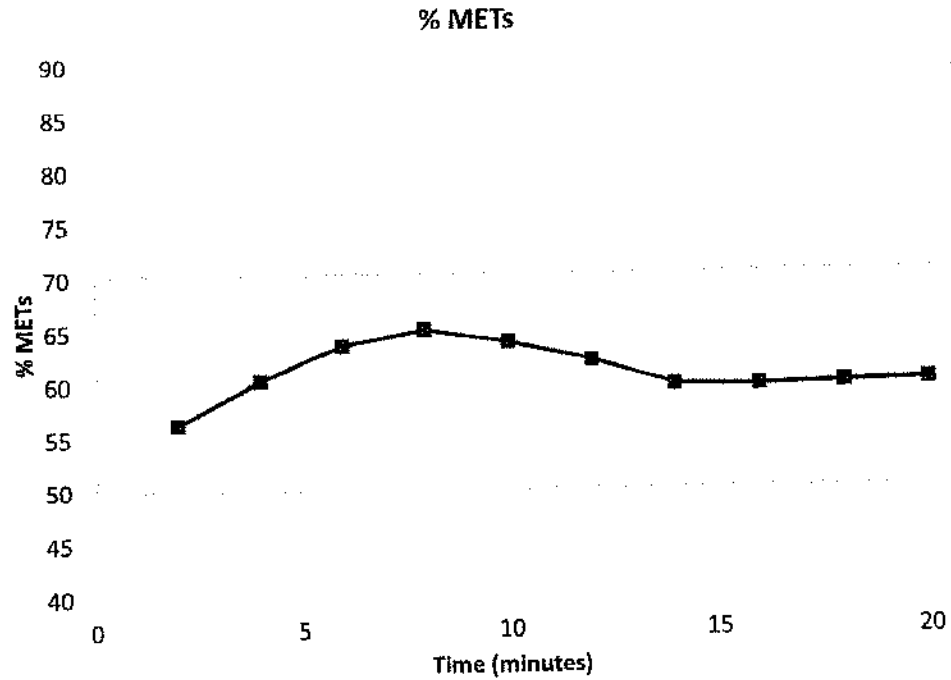


Figure 8. Percent of Maximal METs.

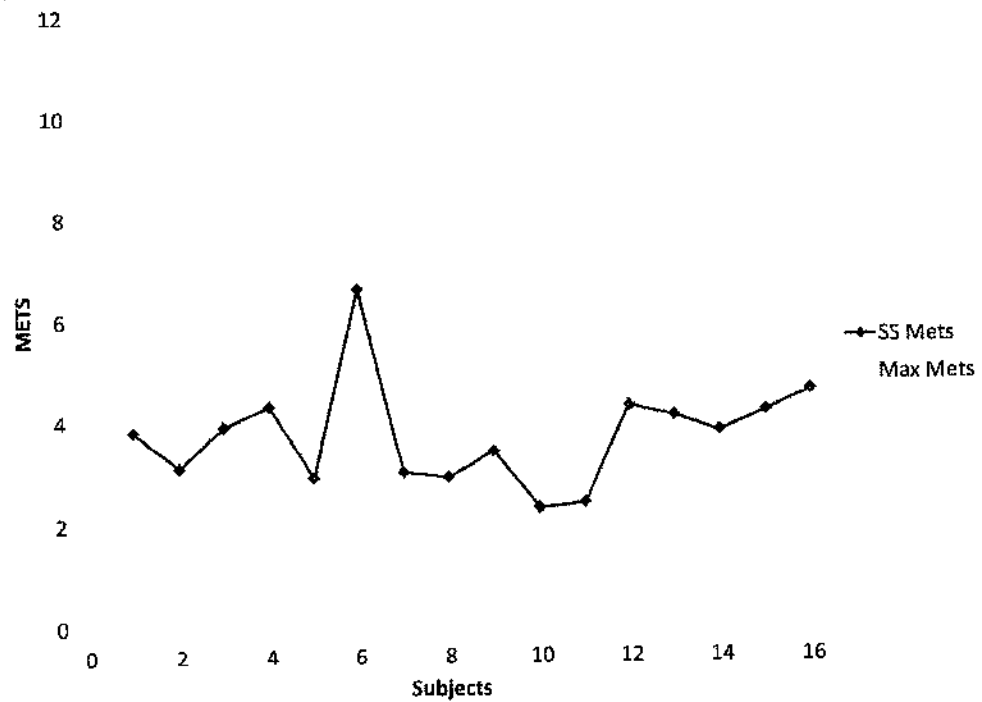


Figure 9. Steady State METs vs Maximal METs

## DISCUSSION

The major finding of this study supports the hypothesis that cardiac patients can self-monitor exercise intensity solely with the TT and stay within ACSM exercise intensity guidelines for % METs, % HRR, and RPE. Average heart rate for the patients ranged between 93-105 bpm which represented 42-63% HRR. The ACSM guideline for moderate intensity is 40-60% HRR (Pescatello et al., 2014) which means the observed average of % HRR was within the guideline range based solely on TT responses. In addition, ACSM also recommends exercising at a RPE of 11-13 for moderate exercise (Pescatello et al., 2014). The patients' average RPE throughout the 20-minute exercise bout ranged from 11.5-13; again within the ACSM recommendations and again within based solely on TT responses. Lastly, when comparing the patients' average percent of maximal METs (56-65%) for their 20-minute exercise bouts to the ACSM guidelines for % METs (50-70%) (Pescatello et al., 2014), the data also shows that the patients were able to complete the 20-minute exercise bout at appropriate exercise intensities using only the TT responses. To anchor the TT process, the subjects recited three verses of "Twinkle Twinkle Little Star" because recent research has shown that the TT is most accurate at identifying the VT when the TT response is 90-110 words (Foss, Foster, Porcari, Mikat, & Schmidt, 2015). Three verses of "Twinkle Twinkle Little Star" is exactly 100 words and is therefore an appropriate passage to use with the TT.

The TT is an effective measure of intensity because it is linked so closely with the VT. Numerous studies have shown the strong correlation between the TT and VT, and the ability to determine exercise intensity at VT using the TT (Ballweg et al. 2013; Dehart-Beverly et al., 2000; Quinn and Coons, 2011; Recalde et al., 2002). Foster et al. (2009) and Jeans. Foster, Porcari, Gibson, & Doberstein (2011) supported the ability of the TT to be used in a submaximal stress test and to use those result to prescribe steady state exercise intensities. In both studies, subjects completed an incremental exercise test using the TT and then successfully completed steady state exercise bouts at the first stage below the last positive TT stage (LP-1) and the second stage below the last positive TT stage (LP-2). Another study showed that cardiac patients were most successful completing a 20-minute exercise bout when exercising at LP-1 and LP-2 intensities. This study also used the TT in an incremental stress test to determine the TT stages and determine exercise intensity (Lyon et al., 2014). Woltmann et al. (2014) was the first study that explored the “clamping” of the TT in young athletes. The researchers determined the various TT stages and had the subjects self-adjust their exercise intensity to yield predictable levels of exercise intensity. Similarly, in the present study the TT was effectively “clamped” at the LP exercise intensity to begin the exercise bout. Although we intentionally increased the workload to ‘unclamp’ the TT (e.g. produce an equivocal TT response), we later ‘reclamped’ the TT at the LP response and then observed the response of other markers of exercise training intensity fell within widely accepted intensity values.

The TT is almost particularly attractive because, in addition to being linked to physiological changes in the body it has the added benefit of being subjective and very

easy to master. The advantage of being subjective is that regardless of any underlying medical condition or medication, the TT can be adjusted to each person who uses it. The study by Díaz-Buschmann et al. (2013) study highlights the importance of choosing the appropriate intensity method for individuals on beta blockers, when the HR response is blunted. They demonstrated the inaccuracies with most HR prediction equations and expressed their concerns with using HR as intensity markers. Instead, the researchers state that using the aerobic threshold, which is essentially the same threshold as VT, is the safest and most efficient method to prescribe exercise intensity to individuals on beta blockers. This recommendation is also consistent with the consensus recommendation of Mezzani et al. (2012) which state that markers of “threshold” are superior to the relative percent concept based on maximal exercise test results.

The only study with contrary results was conducted by Foster et al (2008). While exploring the aspects of the TT during interval training, they found that when subjects exercised in high intensity intervals they were occasionally still able to talk comfortably when above VT. However, since the current subjects were performing steady state exercise, that factor does not impact these results.

The TT has been widely studied and has been validated for a broad spectrum of populations as an appropriate method to prescribe exercise intensity. Using a simple incremental stress test will allow identification of the intensity associated with VT and guide the clinician to an intensity at which to start the subject for steady state exercise. With the support of the present study, individuals will now be able to self-adjust intensity during an acute exercise bout and maintain appropriate levels of exercise intensities.



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APPENDIX A  
INFORMED CONSENT

## **Participant Information and Informed Consent**

**Title:** Can cardiac patients use the Talk Test as the only intensity marker and stay within appropriate intensity ranges?

**Principal Investigator:** Katherine Doro

**Purpose:**

The purpose of the proposed project is to examine whether or not cardiac patients can use only the Talk Test to self-monitor intensity levels and stay within appropriate intensity ranges for the duration of a 30 minutes exercise session.

**Introduction:**

Approximately 20 cardiac patients from Gundersen Health System in La Crosse will be asked to volunteer in a research study during their normal cardiac rehabilitation class. You are being asked to volunteer so that researchers can explore whether or not cardiac patients can use only the Talk Test to self-monitor intensity levels and stay within appropriate intensity ranges for the duration of a 30 minutes exercise session. Although recent research has demonstrated the Talk Test to be an appropriate monitor of intensity for healthy athletes, it has yet to be tested in cardiac patients. Testing will take place during normal cardiac rehabilitation classes and will take approximately 2.5 hours of your time.

**Background:**

The Talk Test (TT) is a less well known subjective measure of intensity that is related to the ventilatory threshold (Dehart-Beverly, Foster, Porcari, Fater, & Mikat, 2000). Since it is a subjective measure of intensity matched with a physiological marker of intensity, it is adaptable each time a person exercises. It also does not require heart rate as a measure of intensity so it is perfect for individuals who may be on medicines impacting the heart rate response to exercise. The idea of the TT stems from Professor Grayson's advice to the British mountaineers of "climb no faster than you can talk" in 1939. Since then the TT has been validated for numerous general populations (young adult, athlete, sedentary, elite athlete Dehart-Beverley et al., 2000; Recalde, Foster, Skemp-Arlt, Fater, Neese, Dodge, & Porcari, 2002; Foster et al., 2009; Rodriguez-Marroyo, Villa, Garcia-Lopez, & Foster, 2013) as well as in cardiac populations (ischemic heart disease, coronary artery disease (CAD), coronary artery bypass graft (CABG) patients and percutaneous coronary intervention (PCI) patients) Voelker et al. 2002; Cannon et al. 2004; Nielsen, et al. 2014; Brawner et al., 2006; Petersen et al. 2014, Lyon et al.

Recent research has explored the potential for the TT to be used as a submaximal, incremental exercise test and then use the results of that test to prescribe steady-state exercise in both normal populations and cardiac patients (Woltmann and Foster, 2013; Lyon et al., 2014). The purpose of the Lyon et al. (2014) study, conducted at Gundersen Health System in La Crosse, WI, was to determine if cardiac patients could complete steady state exercise at certain stages leading up to the ventilatory threshold (VT). The researchers found the cardiac patients could complete the stages if they were well below

the VT, but they had no maximal exercise test data to compare the results with. The Woltmann and Foster (2013) study, examined the physiological impact of clamping the TT at certain intensity levels, forcing subjects to adjust their intensity to stay in the appropriate TT range. Subjects were able to adjust their intensity to stay in the TT ranges and, in fact, reached steady state exercise in some of the stages. The Woltmann and Foster (2013) study, however, was conducted with young healthy adults and not in the cardiac population. These two studies suggest the next step in the evolution and application of the TT, as well as the purpose of this study. Can cardiac patients use ONLY the Talk Test to self-monitor intensity levels and stay within appropriate intensity ranges for the duration of a 30 minutes exercise session?

**Federal Regulation:** "...The following information shall be provided to each subject: (1) a statement that the study involves research, an explanation of the purposes of the research and the expected duration of the subject's participation..." [45 CFR 46.116(a) (1) and for research subject to FDA regulation 21 CFR 50.25 (a) (1)] When appropriate, the consent form should also state "the approximate number of subjects involved in the study." [45 CFR 46.116(b) (5) and 21 CFR 50.24(b) (5)]

### **Procedure:**

All testing will take place at the Cardiac Rehabilitation center in Gundersen Hospital, will take approximately two and half hours, spread across multiple days and will be part of the normal cardiac rehabilitation procedure. You will perform a submaximal incremental walking treadmill test while reciting three verses of "Twinkle, Twinkle Little Star" at the end of every stage. After reciting the Pledge, you will then answer the question, "Can you speak comfortably" with a "yes", "yes but", or "no". The exercise test will end when "no" is said. Your heart rate and rate of perceived exertion will also be monitored throughout the tests. On separate day after the incremental walking test, you will then perform a 20 minute exercise session on the treadmill, reciting "Twinkle, Twinkle Little Star" at the end of every two minutes. If the answer is "yes" to the question "can you talk comfortably", the speed or grade will increase, if the answer is "no" speed or grade will decrease. Once a speed and grade have been established where talking comfortable is *just* comfortable, you will then finish the exercise session at the speed, adjusting only as needed. As a part of the exiting procedure for Cardiac Rehabilitation at Gundersen, you perform a maximal exercise test. The researchers will simply take the data collected in that exiting stress test and use it as a guideline to compare the data from the 20 exercise session. Only one test (the submaximal incremental test) will be outside of the normal operating procedure for Cardiac Rehabilitation at Gundersen.

**Federal Regulation:** "The following information shall be provided to each subject: (1) "...a description of the procedures to be followed, and identification of any procedures which are experimental." [45CFR 46.116(a) (1) and 21CFR 50.24(a) (1)]

### **Risks:**

Other than the common muscle soreness and short-term fatigue associated with exercise tests and the normal low risk associated with cardiac rehabilitation, there are no other risks associated with this study. The risk of complication during cardiac rehabilitation is about 0.1/10,000 hours and will not be changed by participation in this study. A 5-10 minute warm-up and cool-down will be given prior to the start and at the end of the exercise test to reduce the risk of cardiac events and muscular injuries. You will be

monitored through their heart rate and live EKG feed. These measures should be effective at reducing the risks associated with this study.

**Federal Regulation:** "...The following information shall be provided to each subject: (2) a description of any reasonably foreseeable risks or discomforts to the subject." [45CFR 46.116(a) (2) and, 21CFR 50.25(a) (2)]. When appropriate...the following...information shall also be provided to each subject: (1) a statement that the particular treatment or procedure may involve risks to the subject (or to the embryo or fetus, if the subject is or may become pregnant) which are currently unforeseeable." [45CFR 46.116(b) (1) and 21CFR 50.25(b) (1)]

### **Benefits:**

Personally, you will receive no benefit from this study aside from an increased knowledge on exercise testing and intensity markers and access to exercise testing you may not have received elsewhere. Although you will receive no benefit personally, the data will be useful to the exercise community for determining if the talk test is an appropriate measure of intensity for cardiac patients.

**Federal Regulation:** "...The following information shall be provided to each subject: (3) a description of any benefits to the subject or to others which may reasonably be expected from the research." [45CFR 46.116(a) (3) and 21CFR 50.25 (a) (3)]

### **Confidentiality:**

Your identity and the information that is obtained about you during this study will remain confidential to the extent of the law. However, your primary researcher, representatives of the sponsoring company or its agents/designee, and the Human Subjects Committee/IRB may review your medical records to verify study related information and the signed consent form. An IRB is a group of medical and non-medical individuals who have reviewed the study information with the subjects' protection in mind. The results of this study may be published in scientific journals or presented at medical meetings; however, you will not be identified by name.

**Federal Regulation:** "...The following information shall be provided to each subject: (5) a statement describing the extent, if any, to which confidentiality of records identifying the subject will be maintained." [45CFR 46.116(a) (5) For research subject to FDA regulation, this statement must also note "the possibility that the Food and Drug Administration may inspect the records." [21CFR 50.25(a) (5)]

### **Compensation/Cost:**

Investigators of this study will not provide or pay for medical care needed by subjects as a result of participation in this study.

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.

No additional cost above the normal Gundersen Cardiac Rehabilitation fees will result from participation in this study.

In case an injury occurs, contact supervising researcher Carl Foster, Ph.D at (608)-785-8687.

**Federal Regulation:** "...The following information shall be provided to each subject: (6) for research involving more than minimal risk, an explanation as to whether any compensation and an explanation as to whether any medical treatments are available if injury occurs and, if so, what they consist of, or where further information may be obtained." [45CFR 46.116(a) (6) and 21CFR 50.25(a) (6)].

**Federal Regulation:** "...When appropriate the following information shall also be provided to each subject: (3) any additional costs to the subject that may result from participation in the research." [45CFR 46.116(b) (3) and 21CFR 50.25(b) (3)]

**Voluntary Participation and Withdrawal:**

Your participation is entirely voluntary. If you agree to participate, you may choose not to answer any given questions, and may withdraw your consent and discontinue your participation at any time without any negative repercussions.

**Federal Regulation:** "...The following information shall be provided to each subject: (8) a statement that participation is voluntary, refusal to participate will involve no penalty or loss of benefits to which the subject is otherwise entitled, and the subject may discontinue participation at any time without penalty or loss of benefits to which the subject is otherwise entitled. [45CFR 46.116(a) (8) and 21CFR 50.25(a) (8)]

**Contact Person:**

I understand that if I have any questions concerning the purposes or the procedures associated with this research project, I may call Dr. Carl Foster, supervising researcher, at (608)-785-8687. For more information about my rights as a research participant, I may contact Bernard J. Hammes, Ph.D., Chairperson of the Gundersen Clinic, Ltd. Institutional Review Board at (608) 782-7300 or 1-800-362-9567. An institutional review board (IRB) is a group of health care professionals and community members who review research studies to protect the rights and welfare of research participants.

You will be kept informed of any significant new findings that may affect your willingness to participate in this study. In some cases you may be requested to sign a new consent form.

**Statement of Consent to Participate:**

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 and dated copy of this consent form.

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Signature of Participant

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Date

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Signature of Researcher obtaining consent

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Date



\_\_\_\_\_ has read and signed this consent form  
and told  
us there are no questions which 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

\_\_\_\_\_  
Witness Signature Date

**\*\*\*Signature of an impartial witness who has observed the consent process is  
required if the participant cannot read.**

**\*\*\*If the impartial witness is the same person as a witness that signed and dated on  
one of**

**the above Witness Signature lines, they are allowed to initial below.**

**I have observed the consent process as an impartial  
witness. \_\_\_\_\_**

APPENDIX B  
REVIEW OF LITERATURE

## **REVIEW OF LITERATURE**

There are many difficulties that arise when trying to measure intensity for and during exercise. Lack of equipment, impact of medication, and the difficulty of the concept are just a few problems with measuring and monitoring intensity. The Talk Test (TT) is a subjective measure of intensity, so no equipment is needed to apply the TT during exercise that is considered to be fairly accurate but not widely used or recognized. This literature review delves into the evolution of the talk and as well as the applicability of the TT. Although some researchers may not have known the importance their results would have for the TT, fundamental data collection began in the 1980's with the research of the impact of speech on breathing. In 1995, the TT appeared for the first time in research and initiated the rapid growth that developed the TT into what it is today. The various sections within this review of the literature categorize research on or pertaining to the TT into four different sections. When put together the sections lead to the unanswered question of: Can cardiac patients use the TT as a sole measure of intensity and stay within appropriate intensity ranges?

### **Speech Production and Breathing**

Doust, J.H. & Patrick, J.M. (1981). The limitation of exercise ventilation during speech. *Respiratory Physiology*, 46, 137-147.

This article lays the foundation for the evolution of the Talk Test (TT). It begins by explain that speech is created by air from the lungs moving past the vocal chords, causing them to vibrate and therefore, make sound. Since it is during the expiration

phase of ventilation when the air crosses the vocal chords, it stands to reason that speech, at rest, causes a small increase in expiratory airflow. The question this study examined is what happens to expiratory airflow and gas exchange when speaking during exercise, when gas exchange is more necessary. Researchers took six health adults and had them exercise on a treadmill for seven minute stages, with 10 minutes of rest given between stages. The idea was to get the subjects into steady state exercise at certain percent heart rates and see what happens to ventilation and gas exchange once speaking occurs. They had the subjects read a 100 word paragraph at the fifth minute of each stage and measurement of ventilation was taken throughout the test. Since researchers needed the subjects to talk, they couldn't continuously hook them up to a gas exchange monitor, instead they had the subject breath into a pleysmograph for at least five breaths at the second and seventh minute of each stage. This way they could monitor gas exchange as well as ventilation during speech. The results revealed that there was a reduction in overall ventilation, due to a reduction in respiratory frequency, every time speech was introduced. Also shown in the results is that speech causes a significant increase in the length of the expiratory phase. No conclusions about gas exchange were made with this study. Since there was a link between ventilation and speech during exercise additional questions arose starting the development of what is now know as the Talk Test (TT).

Mertens, R.W., Bell, H.J, & Goode, R.C. (2001). The breath sound check and exercise at or about the ventilatory threshold. *Frontiers in Modeling and Control of Breathing*, 375-362.

This study looked deeper into the relationship between the sounds of breathing during exercise in two different experiments. In the first experiment, researchers had seven subjects partake in an incremental stress test on a cycle ergometer and point out

when they could “readily hear” their breathing. The second experiment had nine subjects completing the same exercise test as in the first experiment except subjects pointed out when they could simply “hear” your breathing. Heart rate and gas exchange were recorded in both tests and used as a comparison tool and to determine ventilatory threshold, respectively. Results demonstrated that when a person can hear, and readily hear, their breathing, they are exercising within 15% of their VT and have a heart rate that is at an appropriate intensity range. This study simply looks at breathing, as opposed to speaking, and still demonstrates that VT can be determined without laboratory tests.

Meckel, Y., Rotstien, A., & Inbar, O. (2002). The effects of speech production on physiologic responses during submaximal exercise. *Medicine & Science in Sports & Exercise*, 34(8), 1337-1343.

Although this article could belong in the “Talk Test and Exercise” section, it is here because the researchers looked specifically at what is happening physiologically when speech is included with exercise, as opposed to if speech during exercise is *related* to the physiological changes seen. Fourteen healthy males completed a maximal exercise test and then three exercise sessions at different percent of heart rate. Researchers found that although heart rate and diastolic blood pressure were not impacted by speech, blood lactate and systolic blood pressure increased during the speaking tests. Ventilation decreased during speech and most likely caused the increase in end tidal CO<sub>2</sub> levels, which leads to a decrease in VO<sub>2</sub>. This study shows that regardless of exercise intensity, certain physiological changes were seen within the subjects and had to be attributed to speech. This study is relevant to my study because it demonstrates that speech impacts physiological changes, and therefore could be used to monitor those changes.

Rotstein, A., Meckel, Y. & Inbar, O. (2004). Perceived speech difficulty during exercise and its relation to exercise intensity and physiological responses. *European Journal of Applied Physiology*, 92, 431-436.

This study used 14 young healthy adults to examine the relationship between perceived difficulty speaking during exercise and physiological changes. The subjects had resting pulmonary function tests completed first and then completed an incremental stress test. Researchers had subjects describe their difficulty breathing using an adapted RPE scale called a perceived speech production difficulty (PSPD) scale. The results demonstrated that there is a relationship between several physiological changes (heart rate,  $\text{VO}_2$ , ventilation) and an increased rating on the PSPD scale. This relationship was also seen in study conducted by Meckel et al. in 2002 and helps to explain why talking and difficulty breathing can be used to monitor exercise intensity.

Overall the studies in this section help to lay the foundation for the TT. They discuss the relationship between speech and ventilation, a key factor of the TT. All of these studies show that regardless of exercise, speech impacts physiological factors in the body which easily evolves into using talking to monitor exercise intensity.

### **Ventilatory Threshold and Disease**

Meyer, K., Samek, L., Pinchas, A., Baier, M., Betz, P., & Roskamm, H. (1995) Relationship between ventilatory threshold and onset of ischaemia in ECG during stress testing. *European Heart Journal*, 16, 623-630.

This was the first study conducted utilizing the TT with any population with a disease. The researchers recruited 27 male patients with ST depression and angiographically documented heart disease. They had all of the subjects stop their medications for at least 24 hours before the exercise test. During the maximal exercise

test, oxygen uptake ( $\text{VO}_2$ ), heart rate, rate pressure product, and blood lactate were measured. Patients were also monitored by a 12-lead EKG so researchers could determine when the onset of ischemia (ST depression of at least 10 mV) occurred. The results of this study demonstrated that for every participant the VT occurred before the onset of ischemia. This study really advanced the research of the TT because if there was a way to determine VT without going to lab, that method would be very applicable. At the time this study was conducted, the TT hadn't been fully developed or tested so this study caused numerous researcher to begin exploring the TT.

Voelker, S.A., Foster, C., Skemp-Arlt, K.M., Brice, G., and Backes, R. (2002). Relationship between the talk test and ventilatory threshold in cardiac patients. *Clinical Exercise Physiology* 4, 120-123.

Up to the time of this study, no research had been conducted in validity of the TT to measure the VT in cardiac populations. This study tested ten cardiac patients that had successfully completed cardiac rehabilitation, also known as clinically stable cardiac patients. Two exercise stress tests were conducted, the first using the gas analyzer to determine the VT and the second using the TT. The results demonstrate that even in cardiac patients, when an individual is not able to speak comfortably during the TT, he/she is exercising at or near his/her VT. This data also supported the idea that when people are at a positive or equivocal stage of the TT, they are exercising at a heart rate that is in an appropriate intensity level, based on the ACSM guidelines. This study helped to open the door for the validation and application of the TT in clinical population, even if it was just with clinically stable patients.

Cannon, C., Foster, C., Porcari, J. P., Skemp-Arlt, K. M., Fater, D. C. W., & Backes, R. (2004). The talk test as a measure of exertional ischemia. *American Journal of Medicine and Sports*, 6, 52-56.

This next study expanded on the Meyers et al. study by actually using the TT to measure ischemia, as opposed to just measuring the VT. Researchers tested 19 subjects with ST segment changes on a treadmill using the TT by having them recited the “Pledge of Allegiance” at the end of each stage. They compared subjects’ responses to “can you speak comfortably” with the EKG to see if any stage of the TT correlates to ischemia. Subjects’ heart rate, blood pressure, and rate pressure product were all measured or calculated throughout the test and subjects’ 12 lead EKG was consistently monitored as well. Researchers looked at the responses to the TT with the onset of ischemia and found that if a person is able to speak comfortably while exercising, a positive stage of the TT, they would be exercising below the onset of ischemia. This was the first study to show the applicability of the TT in a clinical population.

Brawner, C. A., Vanzant, M. A., Ehrman, J. K., Foster, C., Porcari, J. P., Kelso, A. J., & Keteyian, S. J. (2006). Guiding exercise using the talk test among patients with coronary artery disease. *Journal of Cardiopulmonary Rehabilitation*, 26, 72-75.

In 2006, a study was conducted that looked at the applicability of using the TT as a way to monitor exercise intensity for patients with coronary artery disease (CAD). Researchers recruited 24 patients with CAD and had subjects perform two different submaximal exercise tests using two different speech protocols, once on a treadmill and once on an indoor track. Subjects recited the “Pledge of Allegiance” at the end of each stage on the treadmill and responded to 12 minutes of prerecorded questions while walking on the track. When on the track, the participants were instructed to self-select a pace that would allow them to speak comfortably and had a reminder given to them during their 12 minute walk. Researchers compared heart rate to TT responses and found



that when subjects were guided by the TT they were able to reach appropriate heart rate levels verified from the heart rates found during VO<sub>2</sub>max test that was first conducted in this study. The researchers also found no difference between the speech protocols nor between modalities, both of which help to improve the applicability of the TT. Since this study was conducted with patients with CAD, it also helps to expand the validation of the TT with different populations.

Zanettini, R., Centeleghe, P., Franzelli, C., Mori, I., Benna, S., Penati, C. and Sorlini, N. (2012). Validity of the talk test for exercise prescription after myocardial revascularization. *European Journal of Preventative Cardiology*, 20(2), 376-382.

By 2012, the TT had been validated for a variety of populations using a variety of modalities. Even with the extension validation, the TT had yet to be validated or used with cardiac patients who underwent cardiac revascularization. Zanettini, Centeleghe, Franzelli, Mori, Benna, Penati, and Sorlini designed a research study looking into this population. They tested 50 cardiac patients with recent myocardial revascularization procedures (either coronary artery bypass graft (CABG) or percutaneous coronary intervention (PCI)). During the beginning of the cardiac rehabilitation program, the subjects performed three different TT and then an exercise stress test during the fifth week of cardiac rehabilitation. Since this study was conducted in Italy, a standard paragraph from the Italian Constitution was given to the participants to recite at the end of each TT stage. Analyzing the various TT tests with the final exercise stress test data, researchers were able to determine that in majority of patients the best stage to optimize training intensity would be the last positive TT stage, right before the equivocal stage (VT). An important aspect of this study is that the subjects in this study were being tested within approximately 30 days of their procedure. The fact that testing occurred so quickly

post-procedure is evidence to rehabilitation clinics that testing protocols using the TT could be utilized immediately when a new patient arrives at rehabilitation.

Díaz-Buschmann, I., Villelabeitia Jaurequizar, K., José Calero, M., & Sánchez Aquino, R. (2013). Programming exercise intensity in patients on beta-blocker treatment: the importance of choosing an appropriate method. *European Journal of Preventive Cardiology*, 0(00), 1-7.

The complication with prescribing exercise intensity in cardiac populations is that most of the individuals with cardiac disease are on medications, specifically beta blockers, which impact their heart rate. Since heart rate, the more common method used for exercise prescription, is seemingly inaccurate for this population an alternative method should be used. This article looked into the inaccuracies of using the heart rate to prescribe intensity as well as the possibility of alternative methods for prescribing intensity. Two-hundred and twelve cardiac patients (53 not treated with a beta blocker, 159 treated with a beta blocker) were a part of this study. Researchers had subjects complete a maximal  $\text{VO}_2$  test with a gas analyzer in order to determine maximal heart rate as well as ventilatory thresholds. Heart rate was determined at certain points throughout the test (resting, maximal, ventilatory threshold, anaerobic threshold, etc) as well as calculated using the Karvonen formula. Researchers were looking to see how many patients were within the aerobic threshold (ventilatory threshold) and the anaerobic threshold when their heart rate or calculated heart rates were at 75%, 80%, and 85%. Results showed that prescribing exercising intensity within the aerobic and anaerobic threshold is the most efficient and safest way to give intensity guidelines to individuals on beta blockers. If determining the aerobic and anaerobic thresholds is not available, then researcher state HR estimation can be used, but with extreme caution. This research

article definitely shows that alternative methods should be utilized when working with individuals on a beta blocker.

Petersen, A.K., Maribo, T., Hjortdal, V.E., & Lausten, S. (2014). Intertester reliability of the talk test in a cardiac rehabilitation population. *Journal of Cardiopulmonary Rehabilitation and Prevention*, 34, 49-53.

The TT has been validated for many populations, however until 2014, it had not been used in a cardiac rehabilitation population, where it may be the most applicable. Petersen, Maribo, Hjotdal, and Lausten (2014), took 64 cardiac rehabilitation patients who had successfully completed the rehabilitation program and examined the validity of the TT with this population and if there was a high intertester (between two different tester) reliability when administering the TT. The subjects completed two incremental exercise stress tests on a cycle ergometer, tested by a different physiologist for each test. The positive part of this test is that the TT appears to be valid for this population. The negative aspect is that there was a poor intertester reliability, meaning patients' score on the incremental exercise tests would vary depending on which physiologist administered the test. Thankfully a simple solution exists for this problem; only have one person administer the TT test for each individual, eliminating the intertester error. This article brought up an important aspect when conducting research, intertester reliability. If more than one person is going to administer the tests, then intertester reliability can cause errors with the data. Fortunately, there will only be one person administering the TT in the proposed thesis project.

Nielsen, S.G., Buus, L., Hage, T., Olsen, H., Walsoe, M., & Vinther, A. (2014). The graded cycling test combined with the talk test is reliable for patients with ischemic heart disease. *Journal of Cardiopulmonary Rehabilitation and Prevention*, 34, 276-280.

The purpose of this study was to validate the TT in addition to a graded exercise test, completed on a cycle ergometer, in ischemic heart disease patients. Although Voelker, Foster, Skemp-Alt, Brice, and Backes (2002) conducted a similar study, this study was conducted on a cycle ergometer, whereas the Voelker et al., study was conducted on a treadmill. Sixty-four patients completed two exercise stress tests within the same day, with two hours of rest between the tests. The TT was administered both times, using the same passage and procedure for each test. The results of this test were in support of those found in 2002 with Voelker et al. and show that the TT can be used in populations with cardiac disease. The importance of this study is the difference in modality when compared to the Voelker et al. study and the fact that even between two different exercise test, the TT was a reliable way to monitor exercise intensity.

Since the purpose of the proposed thesis is to evaluate cardiac patients' ability to self-monitor appropriate exercise intensity levels using only the TT, it was important to evaluate all the previous literature using the TT in cardiac populations. Most of the articles were just examining the validity and reliability of the TT to measure VT within various cardiac populations, not looking into the applicability of the TT to prescribe or monitor exercise intensity. The next step in this research is to evaluate the accuracy of the TT to prescribe and monitor exercise intensity in the cardiac populations.

### **Ventilatory Threshold and Talk Test**

Dehart-Beverly, M., Foster, C., Porcari, J. P., Fater, D. C. W., & Mikat, R. P. (2000). Relationship between the talk test and ventilatory threshold. *Clinical Exercise Physiology*, 2, 34-38.

This first study examines the problem that although the Talk Test (TT) has been around for a few years, no study had directly correlated the TT with the ventilatory threshold (VT). To this point, assumptions had been made, but no data had been presented supported the hypothesis. Researcher for this study tested 28 healthy individuals with two  $\text{VO}_2\text{max}$  tests. The first test used the gas analyzer to get data for the maximal  $\text{VO}_2$  along with the VT. The second maximal test had the participants saying the “Rainbow Passage” at the end of each stage throughout the test. Researchers then analyzed the subjects’ responses during the second treadmill test with the physiological data collected during the first maximal test. The analysis demonstrated that when the subjects below their VT, they were easily able to speak and when they exercised above their VT, they were not able to speak comfortably. This study was the first to validate the relationship between the TT and VT and opened the door for further research.

Recalde, P. T., Foster, C., Skemp-Arlt, K. M., Fater, D. C. W., Neese, C. A., Dodge, C., & Porcari, J. P. (2002). The ‘talk test’ as a simple marker of ventilatory threshold. *South Africa Sports Medicine*, (9) 5-8.

Shortly after the 2000 study was conducted by Dehart-Beverley et al., another study came out looking into the validation of the TT with well-trained adults. Similar protocol to the 2000 study was followed, except this study had subjects read the “Pledge of Allegiance” instead of the “Rainbow Passage”. After participants completed two maximal exercise stress tests, the researchers compared the responses to the TT with the physiological data collected in the first stress test. This study also concluded that there is a valid correlation between the TT and the VT. The main importance with this study is that it validated the correlation between the VT and the TT for a different population than the population used in the 2000 TT study.

Quinn, T. J., & Coons, B. A. (2011). The talk test and its relationship with the ventilatory and lactate thresholds. *Journal of Sports Sciences*, 29(11), 1175-1182.

Close to ten years later, the correlation between the TT and the VT was analyzed again, this time including the relationship between the TT and lactate threshold to the study. This study, conducted by Quinn and Coons, tested a total of 15 participants, first with a lactate threshold and  $\text{VO}_2$  max test and then with a maximal stress test using the TT. The levels of the TT once again correlated with appropriate exercise intensity levels as stated by the ACSM guidelines. The interesting aspect of this study is that, although there was a positive correlation between VT and TT, as seen before, there was a larger correlation between the TT and lactate threshold. This study helps to demonstrate the applicability of the TT in monitoring exercise intensity as well as assist in validating the correlation between not only the TT and VT, but also the TT and the lactate threshold.

Ballweg, J., Foster, C., Porcari, J., Haible, S., Aminaka, N., Mikat, R.P. (2013). Reliability of the talk test as a surrogate of ventilatory and respiratory compensation thresholds. *Journal of Sports Science and Medicine*, 12(3), 610-611.

By 2013, the TT has been validated for several populations using several different modalities, but it had yet to be tested on its reproducibility when being compared to the gas exchange method for determining VT. Researchers tested 24 healthy adults using the cycle ergometer. The subjects completed a total of four exercise tests, two using gas exchange and two using the TT and reciting the "Pledge of Allegiance". There were no significant differences between any of the tests, exercise test or TT, and all of the tests were able to accurately measure the VT, showing high reproducibility of the TT. This study helps to further validate the scientific evidence that demonstrates the Talk Test's ability to measure VT.

Rodriguez-Marroyo, J. A., Villa, G., Garcia-Lopez, J., & Foster, C. (2013). Relationship between the talk test and ventilatory threshold in well-trained cyclists. *The Journal of Strength and Conditioning Research*, 27(7), 1942-1949.

The validation study of the TT and VT in 2013 is unique because it takes a look at a population of elite athletes, helping to further show the applicability of the TT across the physical fitness spectrum. Researchers tested 18 elite cyclists, first with the maximal test to determine VT and secondly with the TT. Since this study was conducted in Spain, the subjects read a paragraph from a common Spanish poem. Once again, the results show a direct correlation between the TT and the VT. With the completion of this study, the relationship between the VT and the TT has been validated in almost every population in the physical fitness spectrum, from sedentary individuals to elite athletes, demonstrating the wide applicability of the TT.

All of these articles help to validate and demonstrate the applicability of the TT. Without confirming the hypothesis that the TT is related to the VT, no further application of the TT could be done. The TT works, and works well, because it can measure the VT, a physiological marker that is accepted in the scientific world as an accurate measure of exercise intensity. The ultimate goal of the TT is to be able to prescribe and monitor exercise intensity by simply saying “exercise at a point where you can just talk comfortably.” The scientific reason, as shown by these articles, is that the TT can relate to the VT.

### **Talk Test and Exercise Prescription**

Goode, R. C., Mertens, R., Shaiman, S., & Mertens, J. (1998). Voice, breathing, and the control of exercise intensity. *Advances in Experimental Medicine and Biology*, 450, 223-229.

This article focuses on the importance of developing an alternative technique for exercise intensity besides having laboratory testing conducted. Nineteen young adults were subjects and were tested on both an indoor track and cycle ergometer. Standard laboratory measurements were taken and show that although subjects reached higher heart rate,  $\text{VO}_2$  and ventilatory threshold markers while jogging on the track, all subjects regardless of modality reached at least 50% of  $\text{VO}_2$ . The importance of this study is that in addition to standard laboratory measurements, the researchers also had subjects raise their hand when they could hear their breathing. Researchers noted the time and exercise intensity at this point and concluded that when subjects could hear their breathing, they were exercising at 60-90% of max heart rate, putting them in the training zone according to ACSM. The biggest importance of this study is that it is the first to link heart rate with being able to hear your breathing.

Carey, D.G., Schwarz, L.A., Pliego, G.J., & Raymond, R.L. (2005) Respiratory rate is a valid and reliable marker for the anaerobic threshold: implications for measuring change in fitness. *Journal of Sports Science and Medicine*, 4, 482-488.

The purpose of this article was to determine how reliable and valid the respiratory rate is in determining the anaerobic threshold. This study used fifteen male competitive cyclists and had them complete two  $\text{VO}_2$  max test on the cycle ergometer. Respiratory rate, ventilation, ventilatory equivalent were all measured in addition to  $\text{VO}_2$  and heart rate. All subjects met at least two of the criteria for a successful  $\text{VO}_2$  max test and had a mean  $\text{VO}_2$  of 66.5 ml/kg/min, demonstrating their high level of fitness. The results of this study support the hypothesis of respiratory rate being an accurate way to measure the anaerobic threshold. The application of this study to my own thesis is showing how



simple aspects of breathing, like how fast someone is breathing, can accurately measure or predict the ventilatory threshold.

Foster, C., Porcari, J. P., Anderson, J., Paulson, M., Smaczny, D., Webber, H., & Doberstein, S. T. (2008). The talk test as a marker of exercise training intensity. *Journal of Cardiopulmonary Rehabilitation and Prevention*, 28, 24-30.

This article was a pivotal piece in the evolution of the talk test. The article actually discusses four different experiments, designed on manipulating either exercise or the subject to see whether the talk test remains a valid manner to estimate ventilatory threshold. The first experiment, the researchers had the subjects donate one pint of blood after completing a  $\text{VO}_2\text{max}$  test and then retested them within 48 hours of the blood donation. The second trial involved a six-week training program, where ventilatory threshold and the talk test were measured prior-to and after the training program. In the third experiment, the researchers had the subjects participate in the talk test while exercising for 30 minutes at intensity levels varying above and below the subject's ventilatory threshold. The final experiment involved measuring the amount of time it took for subjects' speech to be uncomfortable once exercise intensity was raised above the ventilatory threshold. The results of all of these trials clearly demonstrate that even by manipulating exercise intensity and the subject, the talk test can reliably and accurately estimate the ventilatory threshold.

Foster, C., Porcari, J. P., Gibson, M., Wright, G., Greany, J., Talati, N., & Recalde, P. (2009). Translation of submaximal exercise test responses to exercise prescription using the talk test. *Journal of Strength and Conditioning Research*, 23(9), 2425-2429.

At this point in time, the talk test has become validated for being able to accurately measure ventilatory threshold, but it hadn't been demonstrated as an

applicable way to conduct a stress test and then be able to prescribe exercise. This study focused on validating both of these concepts. Researchers used 14 sedentary young adults for the study and had them complete an incremental exercise test, using the Balke protocol until exhaustion. Then subjects came back and performed three 20-minute exercise bouts at different levels of intensity (LP-1, LP, EQ) determined by the incremental test, in relation to the ventilatory threshold. All levels of intensity were within the recommended ranges for training, but at the end of the EQ stage, heart rate did drift upwards, showing intensity may be borderline high. Since exercise intensity was borderline high, this study recommends exercising at the LP or LP-1, which are still appropriate levels of intensity. The key importance of this study is the connection between the incremental stress test and the ability to prescribe exercise intensities based off of it. The applicability of this for clinical settings is a key step in demonstrating the importance and value of the stress test.

Jeans, E. A., Foster, C., Porcari, J. P., Gibson, M, and Doberstein, S. (2011). Translation of exercise testing to exercise prescription using the talk test. *Journal of Strength and Conditioning Research*, 25(3), 590-596.

This study was very similar to the study conducted by Foster et al. in 2009. Fourteen well trained young adults completed two incremental exercise tests and then proceeded to complete 40 minute steady-state exercise sessions. The same three stages that were used in 2009 (LP-1, LP, and EQ) were used in this study and the results demonstrated that when exercising at LP-1 and LP, heart rate were in appropriate training ranges. In support of the 2009 study, the subjects exercising at the EQ stage had high heart rates and RPE values, unsustainable for longer term exercise. The end results show that an incremental stress test using the Talk Test can accurately measure levels of

ventilatory threshold and provide appropriate exercise intensity ranges as well. Since this study used well trained adults, and the 2009 study used sedentary adults, there is adequate evidence that the Talk Test as exercise prescription works throughout the full spectrum of physical fitness found in adults.

Loose, B. D., Christensen, A. M., Smolczyk, J. E., Roberts, K. L., Budziszewska, A., Hollatz, C. G., & Norman, J. F. (2012). Consistency of the counting talk test for exercise prescription. *Journal of Strength and Conditioning*, 26(6), 1701-1707.

The Talk Test is typically conducted with the “Pledge of Allegiance” or the “Rainbow Passage” but another style to conduct the Talk Test is known as the counting method. This study’s purpose was to look into the how consistent the Counting Talk Test (CTT) is at giving appropriate exercise intensity ranges when used with a variety of exercise modalities in 37 healthy women. The study first conducted a VO<sub>2</sub> max test to determine maximal heart rate, which would be used to pick intensity levels in the next two exercise sessions. During each exercise session, the subject exercised with two different modalities each time, so as to test the CTT in a total of four different exercise modalities. During each exercise session, the participants partook in the CTT, with the number of words spoken with each breath estimated by taking a percent of totals words spoken during the resting CTT. The relationship between the percent heart rate with the percent CTT had a high degree of reliability. This study not only shows that the CTT is a reliable way of prescribing exercise, but that it also works with multiple different forms of exercise modality.

Lyon, E., Menke, M., Foster, C., Porcari, J.P., Gibson, M., Bubbers, T. (2014). Translation of incremental talk test responses to steady-state exercise training intensity. *Journal of Cardiopulmonary Rehabilitation and Prevention*, 34(4), 271-275.

Since past research has demonstrated that the TT can measure VT and is valid for various populations on multiple modalities, the next step was to examine at what TT stage should people exercise at in order to perform steady-state exercise. Lyon, Menke, Foster, Porcari, Gibson, and Bubbers (2014), tested 30 outpatient cardiac rehabilitation patients using an incremental exercise test on the treadmill. After using the incremental test to determine the stages of the TT, the subject then performed three 20-minute exercise session, one at the last positive stage (LP) (the last stage where speech was definitely comfortable) and the two stages prior to the LP (LP-1, LP-2). All subjects were able to complete the steady-state exercise at the LP-2, but not everyone was able to finish the 20 minutes at LP-1 and even less finished the LP. Given the data, researchers therefore recommend that for cardiac patients, exercise intensity should be prescribed for the LP-1 and LP-2 stages. This recommendation should be very applicable in the cardiac rehabilitation programs, making the TT even more applicable and easy to use.

These six articles very nicely show the beginning and evolution of the Talk Test (TT) utilized as a modality for exercise intensity prescription. Beginning in 1998 and simply demonstrating the connection between the ability to hear your breathing and heart rate to validating the TT for various populations and exercise modalities, the TT has come along from the start. These articles also demonstrate the importance and applicability of the TT when it comes to the use of the TT in the field of exercise intensity prescription. The studies demonstrated that levels of the TT can provide appropriate steady-state intensity levels through a simple incremental exercise test, eliminating the need for a VO<sub>2</sub> max test.

## **CONCLUSION**

A significant amount of research had been conducted in the hopes of showing the scientific world that the TT is a valid, easy, and appropriate method to prescribe and monitor exercise intensity. Although further research is still needed, the hope is that one day soon prescribing exercise will be as easy as saying “exercise at a point where speaking is just comfortable” regardless of any medical conditions a person may have. The foundation of the TT started with examining what impact speech has on ventilation and the Meyer et al. (1995) study. Since 1995, the TT researchers have validated the relationship between the TT and VT, demonstrated the reliability and validity of the TT to prescribe exercise intensity, and established the usefulness of the TT in populations with diseases. All of this research leads up to the current question of: Can cardiac patients use the TT as a sole measure of intensity and stay within appropriate intensity ranges?

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