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CAN THE TALK TEST IDENTIFY THE RESPIRATORY COMPENSATION THRESHOLD?

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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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.

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ABSTRACT

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Introduction: The Talk Test has shown to be an effective way of determining prescribed exercise intensity and its responsiveness to physiological markers such as ventilatory threshold (VT) and respiratory compensation threshold (RCT) in a variety of populations. The purpose of this study is to extend the results of previous studies to determine if the RCT is correlated with the negative stage of the TT. Methods: Well-trained athletes (n=12) performed two incremental tests. One test included measurement of respiratory gas exchange to determine VT and RCT. The other test involved performing the TT during an identical exercise protocol. Subjects read a standard paragraph 90-100 words at the end of each exercise stage and reported their ability to speak comfortably. Results: There was a moderate strong correlation between VT and LP along with RCT and NEG TT. There was significant differences between mean Watts at VT and mean Watts at the EQTT. The results suggest at the VT is slightly higher than the EQTT and the LPTT. Conclusion: The TT may be used as a simple and non-invasive method to determining exercise intensity for well-trained athletes.

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INTRODUCTION

It is well known throughout the exercise community that physical activity is beneficial to health and wellness and to improve athletic performance. Evidence to support the inverse relationship between physical activity and premature mortality, CVD/CAD, hypertension, stroke, osteoporosis, Type 2 diabetes mellitus, metabolic syndrome and obesity continues to accumulate (ACSM, 2010). Based on extensive studies exercise prescription has been defined by relative physiological measures such as heart rate (HR_{max}), heart rate reserve (HRR), oxygen uptake (VO_2max), percent oxygen uptake (%VO_2max), peak power output (PPO), ventilatory threshold (VT), lactate threshold (LT), respiratory compensation threshold (RCT), and maximal lactate steady state (MLSS) (ACSM, 2014; Mezzani et al. 2012). Drawbacks are that these types of measures often require maximal testing, the lack of trained professionals to conduct maximal exercise testing, and the expense associated with exercise testing.

Exercise guidelines for both general populations and special populations have been developed by the American College of Sports Medicine (2010). Based on the FITT-VP principle, exercise prescription is represented by frequency, intensity, time, type, volume and progression. While frequency, time, type, volume and progression are straightforward, intensity prescription is unhealthy and more confusing; particularly, with athletic and clinical populations. This was recognized a generation ago by Katch, Weltman, Sady, & Freeson (1978). They compared VT vs % HRR prescription and demonstrated the "relative percent concept of intensity did not always produce the same results when warranted on the basis of more sensitive criteria like the ventilatory threshold. Scharhag-Rosenberger et al. (2009) reinforced this concept. These concerns, together with the practical difficulties of exercise testing, have led to the rise of subjective methods of measuring prescribing exercise.

The Rating of Perceived Exertion scale (RPE) (Borg, 1998) is one of the most popular subjective methods of determining training intensity in the field of exercise physiology, particularly in cardiac rehab programs, due to the ease and low cost (cf. Eston, 2012). RPE controlled training has been shown to be associated with thte consistent and predictable increases in VO_{2max} and VT in sedentary individuals (Parfitt, Evans & Eston, 2012).

Another subjective method that is gaining popularity is the Talk Test (TT). The concept for the TT began in 1937, when Professor Henry Joseph Grayson gave advice to British mountaineers to "climb no faster than you can speak" (Goode, Mertens, Shaiman & Mertens, 1998). Little did Grayson know, that he would be setting the foundations for measuring exercise intensity in the future. Goode et al. (1998) suggested if you could hear yourself breathing during exercise, then you are exercising at a pace that is approximated VT. Goode had male subjects participate in three ergometer tests. The workload was increased by 25 Watts at 60-second intervals. As soon as the subjects could "hear their breathing," they were kept at a constant pace for 5 minutes. Heart rate was monitored and recorded. This procedure was repeated a few days later with the same subjects but during running. Both tests showed the same basic findings; heart rate at the point that breathing could be heard corresponded with 60-90% of maximal heart rate. In 1991, the TT was included in the ACSM Guidelines for Exercise Training (volume 4), but did not gain the acceptance compared to other methods such as the Karvonean method, VO_{2max}, VT or techniques based on blood lactate (Meyer, T, 2012). Since, that time numerous evidence based studies have emerged to support the validity of the TT. Although it has not been returned to ACSM Guidelines, the TT has emerged as an important technique and standard TT approaches has evolved (Brawner et al. 2006; Cannon et al. 2004; Dehart-Beverley et al. 2000; Foster et al. 2008; Foster et al. 2012; Voelker et al. 2001; Loose et al. 2012; Norman, Kracl, Parker & Richter, 2002; Norman, Hopkins, & Crapo, 2008; Zanettini et al. 2013).

Various studies have demonstrated the validity of the TT. In 2002, Mikel et al. looked at the cardiopulmonary and metabolic responses to speech during exercise of varying intensities in healthy, young men. They showed the decrease in VO_2 during speech while exercising was accompanied by a significant drop in ventilation and an increase in blood lactate [HLa]. Breathing frequency, which normally increases at the VT and RCT also decreased during speech. Dehart-Beverley e. al. (2000) demonstrated the TT is a measure of VT in healthy adults. Similarly, the relationship between the TT and VT was also seen in well-trained cyclists (Rodriquez-Marroyo, Villa, Garcia-Lopez, & Foster, 2012), patients with coronary artery disease (Brawner et al., 2006; Volker et al., 2001), sedentary individuals (Foster et al., 2009) and patients with a recent myocardial revascularization (Zanettini et al., 2013). Foster et al (2008) went on to test the validity of the TT by manipulating the VT and showed it to be a reliable marker of VT. Persinger et al. (2004), studied the consistency of the TT as a marker of the VT in different modes of exercise. Subjects were tested on the treadmill and the cycle ergometer. The results showed the VT for both the treadmill and cycle ergometer were similar to the TT. The study also concluded the LP and EQ stages at the TT were within the ACSM intensity guidelines, while the NEG stages of the TT exceeded the recommended guidelines. Recalde et al. (2002) focused on an athletic population by testing well-trained individuals. The LP stage of the TT was consistently below the VT and the NEG stages of the TT was almost exactly at the RCT. These results are not only similar to Dehart-Beverley et al. (2000) and Voelker et al. (2002), but they indicate that the TT can be applied as an exercise prescription method in very active populations. A study conducted by Woltmann examined what happened to exercise intensity, HR and [HLa] when the exercise condition defined by the TT was held constant. The results support the TT can be used proactively to control exercise intensity below the LT and maximal lactate steady state (MLSS) in well-trained adults.

Research had confirmed the validity and reliability of the TT by standardizing a protocol and has identified that the TT is a surrogate of the VT. Simultaneously, the TT has also been evaluated to ensure its reliability (Ballweg et al. 2014; Peterson et al. 2014). In 2004, Cannon et al. 2004 tested the TT as an appropriate tool for avoiding ischemia in clinical populations. They found that the TT preceded the ischemic threshold and occurred at a HR 10 bpm below the onset of ischemic ECG findings. Brawner et al. in 2006 focused on studying the ability of the TT to guide exercise in clinical patients with coronary artery disease (CAD). The data supported the validity of the TT. Zanettini et al. (2012) validated the optimal level of training intensity in patients with recent myocardial revascularization. Their data from this study were compared and the workload range between the patient's aerobic and anaerobic threshold was considered the optimal training zone based on the LP stage of the TT.

The TT protocol is simple and easy to follow. The subject performs an incremental test to exhaustion with stages of 2-3 minutes duration to calculate the VT, RCT and VO_{2max}. A subject performs a second incremental exercise test. In the last 30 seconds of each stage, the subjects recite a standard speech-provoking stimulus (90-100 words) and are asked, "Can you speak comfortably?" Only three responses are allowed; a positive (POS) TT, which in our study will indicate as either the Last Positive stage (LP) or the stage prior to the Last Positive Stage (LP-1), an equivocal response (EQ), and a negative (NEG) response. The subject must be able to speak comfortably while exercising for a POS TT. If the subjects are hesitant about speaking comfortably (e.g. yes, but), this results in an EQ TT. If the subject is not able to speak comfortably or at all, it is a NEG TT. Subjects read a standard 90-100 word paragraph during the last thirty seconds of each stage, (The Pledge of Allegiance or the Rainbow Passage).

With the research that has been conducted, it is safe to conclude that: 1) exercise intensity can be prescribed using the TT, 2) the TT is a valid method of measuring physiological markers such as VT and the RCT and, 3) the TT is an appropriate method of measuring exercise intensity in a wide variety of populations. Therefore, the purpose of the present study is to extend the results of Recalde et al. (2002) and Rodriguez-Marroyo et al. (2012) to determine if the RCT is correlated with the negative stage of the TT. In this study, it is hypothesized: 1) if the TT is negative, the exercise intensity would approximate the RCT. With these results, it is hoped to extend the TT to the prediction of the MLSS and improve training methods for coaches and athletes.

METHODS

Experimental Approach to the Problem

To re-validate the idea that the TT can be used to estimate the VT and RCT, 12 well-trained cyclists were used. Each performed two different incremental tests. One test included measurement of respiratory gas exchange to determine the VT and RCT (Rodriquez- Marroyo et al, 2013). The other test involved performing the TT during an identical exercise protocol, without the use of the respiratory apparatus. During this second test, the subjects read a standard paragraph of 90-100 words at the end of each exercise stage and reported their ability to speak comfortably. The first stage at which the subject could not speak comfortably (EQ) or definitely cannot talk comfortably (NEG) was compared with the VT and RCT analyzed using respiratory gas exchange. The tests were separated by a minimum of 48 hours. The subjects refrained from heavy exercise for 24 hours before testing.

Subjects

The subjects were healthy, well-trained student volunteer athletes from the University of Wisconsin-La Crosse Triathlon Team and Cycling Club (Table 1). All provided written informed consent, and the protocol was approved by the Institutional Review Board for the Protection of Human Subjects at the University of Wisconsin-La Crosse. All subjects were regular exercisers (minimum of twelve hours of cycling weekly). Most subjects performed multiple annual triathlon races each year.

Table 1. Descriptive Physical Characteristics of the Subjects (Mean ± Standard Deviation)

Variable	Men (n = 7)	Women (n = 5)	Total (n = 12)
Age	32.3 ± 18.00	26.4 ± 13.00	29.8 ± 16.00
Height (cm)	181 ± 4.4	166 ± 7.1	175 ± 9.5
Mass (kg)	76.4 ± 3.8	64.2 ± 6.6	71.3 ± 7.9

Procedures

Exercise Tests with Gas Exchange Measurement

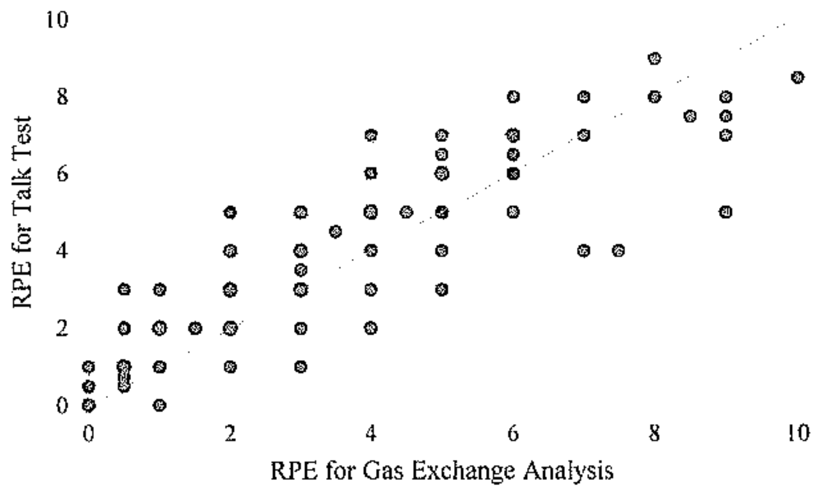
The test was performed on an electrically braked cycle ergometer (Lode Excalibur Sport; Groningen, Netherlands) and was preceded by a four minute warm-up period at an incremental workload that was adjusted each minute (25, 50, 75, 25 W respectively). The initial power output was 25 W and was increased by 25 W every 2 minutes until volitional exhaustion. The maximal power output was determined as the highest workload a cyclist could maintain for a complete stage, interpolated for incomplete stages.

The HR response was measured using radiotelemetry (Polar Vantage NV; Polar Electro Oy, Kempele, Finland), and the respiratory gas exchange was continuously measured using a mixing chamber band metabolic cart (AEI, Bastrop, TX) with data integration every 30-seconds. The following gas exchange variables were measured: VO_2, ventilation (V_E), ventilatory equivalent for oxygen ($V_E \cdot VO_2^{-1}$), and carbon dioxide ($V_E \cdot VCO_2^{-1}$), tidal volume (TV) and breathing frequency (BF). During the last 15 seconds of each exercise stage, the Rating of Perceived Exertion (RPE) was recorded using the category ratio (0-10) RPE scale (Borg, 1998).

Talk Test

The TT exercise protocol was identical to the exercise tests with gas exchange measurements but without respiratory gas analysis. Instead, the cyclists recited a standard paragraph (101 words), the *Rainbow Passage,* during the last 30 seconds of each exercise stage. A cue card was located in front of the cyclists to allow immediate reference to the text. Immediately after reciting the passage, the cyclist was asked, "Can you speak comfortably?" Only 3 possible answers were recorded: "Yes" (+), which referred to as a positive (POS) result; "Yes/but" (+/-) which referred to as an equivocal (EQ) result; and "No" (-), which was referred to as a negative (NEG) result. The last exercise stage at which the cyclists were still able to speak comfortably was referred to as the last positive stage (LP). The first stage at which the cyclists were not entirely certain about their ability to talk comfortably was referred to as the equivocal stage (EQ). Finally, the first stage at which the cyclist could definitely not speak comfortably was referred to as the negative stage (NEG). Starting from this stage, subjects did not have to continue to perform the TT passage, although the protocol was continued another minute into the next stage.

Parameters analyzed in the TT were identical to those analyzed during the exercise test with gas exchange measurement. It was assumed that the respiratory and metabolic response during the TT was the same as during the test with VO_2 measurement. This was confirmed by comparing the HR and RPE responses during the two tests (Figure 1). The cyclists maintained a pedaling cadence above 80 rpm. Seat position, handlebar heights, and shoes were kept constant for both tests.



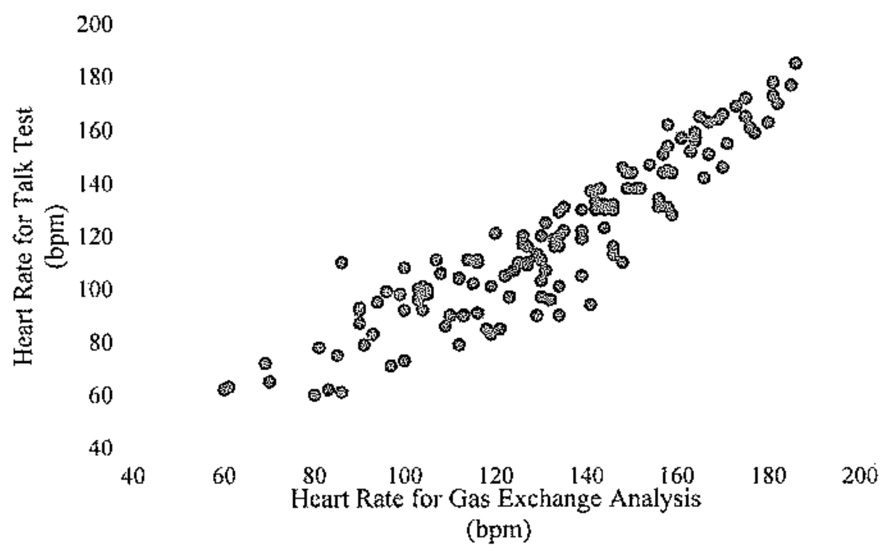


Figure 1. HR and RPE Responses Compared to the Ventilatory Gas Analysis and the TT

Statistical Analysis

The results are expressed as mean ± SD. SPSS + V.23.0 statistical software (SPSS, Inc., Chicago, IL, USA) was used. A two-way ANOVA with repeated measures was used to determine the physiological responses of VT and RCT, and the three indices of the TT between genders. Interaction between genders were not significant, therefore group totals were used for data analysis in this study. The effect size for this analysis (d = 1.72) was found to exceed Cohen's (1988) convention for a large effect (d = .80). Approximately 9 subjects would be needed to obtain statistical power at the recommended .80 level. Alpha was set at $p \leq 0.05$ to be considered statistically significant. Outliers were determined for the data and removed. Pearson product moment correlations were used to support conclusions drawn from the primary ANOVA analysis. The relationship between variables were determined by means of Pearson's correlation coefficient (r).

RESULTS

The physiological maximal values that were measured during the gas analysis are represented in Table 2. The relationship between the VT and LPTT and EQTT are presented in Figure 2a and 2b, respectively. There were a moderate correlation between VT and LP (r = 0.836) and EQ (r = .806). There were significant differences between mean Watts at VT (214 ± 43.5) and watts at LP (165 ± 51.6). There were significant difference between Watts at VT (214 ± 43.5) and mean Watts at the EQ TT (181 ± 33.9).

Table 2. Maximal Values Measured During Exercise Gas Analysis (Mean ± Standard Deviation)

Variable	Men (n = 7)	Women (n = 5)	Total (n = 12)
VO_{2max} ($L{\cdot}min^{-1}$)	4.8 ± 0.40	3.3 ± 0.61	4.2 ± 0.91
VO_{2max} ($mL/kg^{-1}/min^{-1}$)	63.1 ± 6.84	51.1 ± 7.09	58.1 ± 9.05
Peak Power Output (W)	326 ± 25.7	230 ± 41.1	285 ± 58.3
Peak Power Output ($W{\cdot}kg^{-1}$)	4.3 ± 0.42	3.6 ± 0.52	4.0 ± 0.56
Power Output at VT (W)	235 ± 27.0	184 ± 46.6	214 ± 43.5
Power Output at RCT (W)	297 ± 32.0	253 ± 62.3	278 ± 50.0
VO_2 at VT ($L{\cdot}min^{-1}$)	2.3 ± 0.24	1.8 ± 0.46	2.1 ± 0.43
VO_2 at RCT ($L{\cdot}min^{-1}$)	2.9 ± 0.34	2.5 ± 0.62	2.7 ± 0.51
Power Output at LPTT (W)	186 ± 55.6	135 ± 28.5	165 ± 51.6
Power Output at EQTT (W)	196 ± 30.4	160 ± 28.5	181 ± 33.9
Power Output at NEGTT (W)	271 ± 52.9	210 ± 22.4	249 ± 52.0

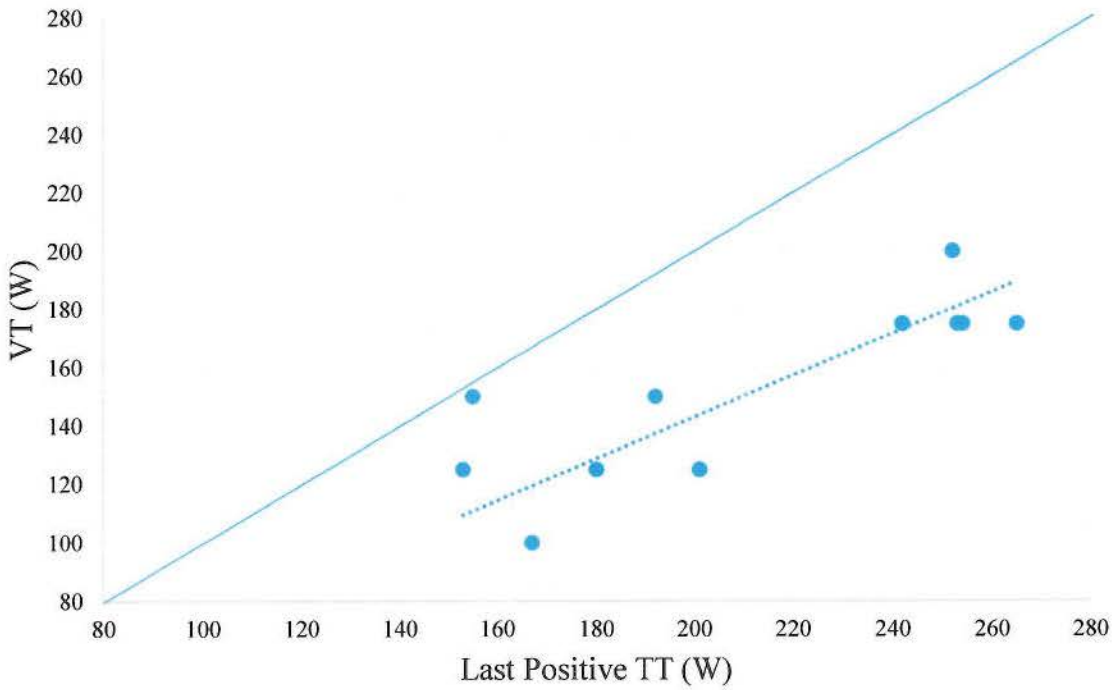


Figure 2a. Relationship between the VT and the LPTT

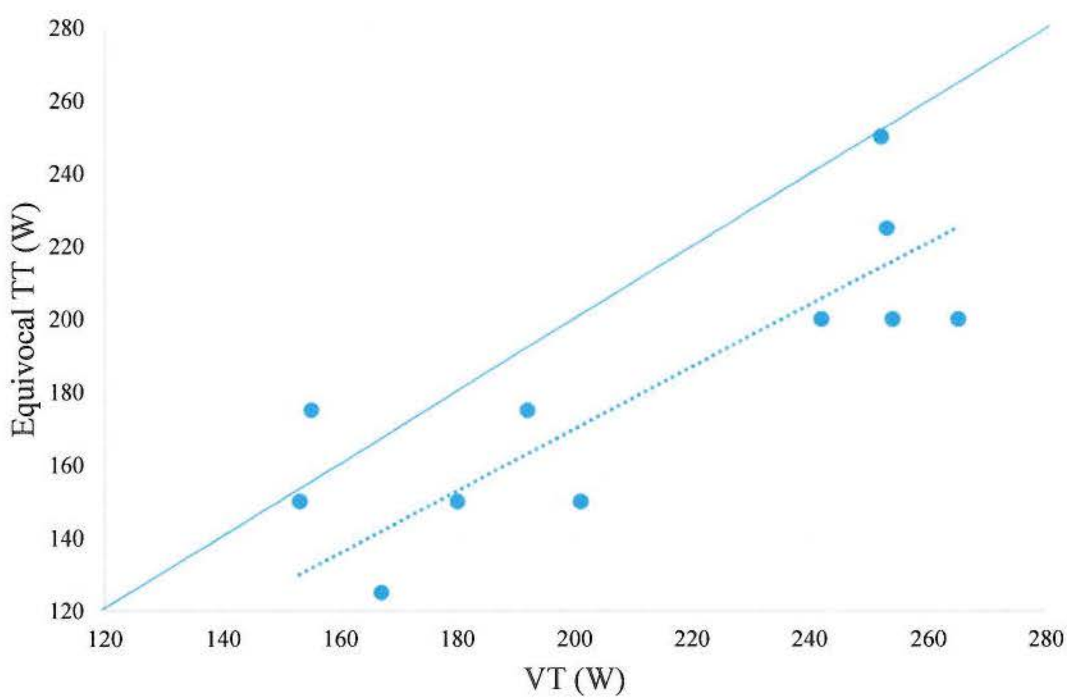


Figure 2b. Relationship between the VT and the EQTT

The relationship between the RCT and the NEG TT is presented in Figure 4. There was a moderate correlation between Watts at RCT and NEG TT Watts ($r = 0.619$). There were significant differences between watts at RCT (278.8 ± 50.02) versus NEG TT Watts (245.8 ± 52.04) ($p \leq 0.05$).

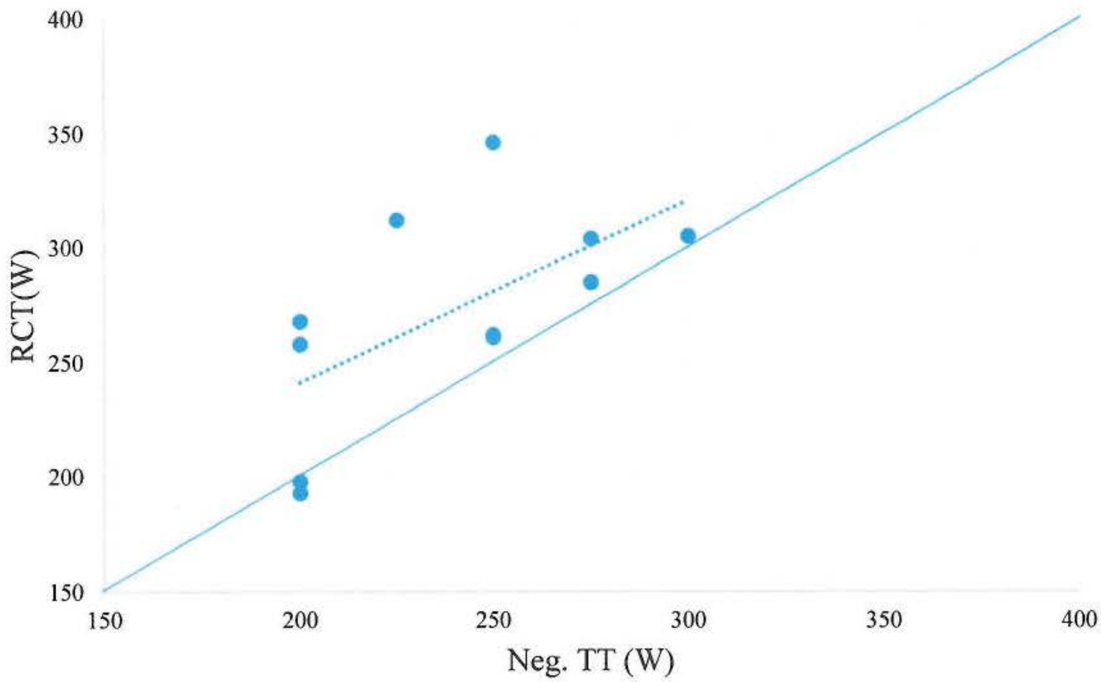


Figure 3. Relationship between the RCT and the NEG TT

DISCUSSION

The results obtained in this study support the hypothesis that TT is a surrogate of the VT and RCT in highly trained cyclists. These data agree with those obtained in previous studies with other populations. These studies have shown that with high level athletes, sedentary individuals, or patients with chronic disease, there is a good correspondence between the VT and the EQ (Dehart-Beverley, 2000; Voelker, 2002; Quinn & Coons, 2011; Persinger et al, 2004; Meyer, 2004; Cannon, 2004; Foster et al. 2008; Zanettini et al. 2013; Lyon, 2014; Woltmann et al. 2015). Our results support data reported previously by Recalde et al. (2002) and Rodriquez-Marroyo et al. (2013) in correlation to RCT and NEG TT, altering all the TT measures tended to underestimate VT and with RCT.

The data that was obtained for the EQTT and the LPTT were specific to the VT but the values were slightly lower than VT by approximately 10%. These results disagreed, to an extent, with the findings of Quinn and Coons (2011). These authors found that the values analyzed at the VT were significantly under-represented values measured at all three levels of the TT. These authors used a different protocol to perform the TT and the lactate threshold test (3-minute stages) compared to our study (2-minute stages) for analyzing the VT. It has been shown that VT is affected by the exercise protocol (Quinn & Coons, 2011).

A possible limitation to the TT may have affected the results. Each subject was given the same explanation and definition of the TT and its responses with possible answers. However, the accuracy of the TT directly depends on the subject's ability and willingness to answer correctly.

If the subject claimed they could speak comfortably when they could not, the data would be overestimated, while if the subject claimed they could not speak comfortably when they really could or did not know or change their mind, the exercise capacity would be underestimated. This seemed to occur with the subjects at the EQ and the NEG stages of the TT due to the subjects struggling on the concept of when they could actually not speak "comfortably" or not being able to speak as long as they had anticipated. This could warrant a deviation in the calculated VT and RCT. Another limitation was test anxiety by subjects due to not providing a habitual ride. Some of the subjects were not familiar with gas analysis exchange and found it more difficult to achieve their maximal workload without any prior training or expectations.

The data that was collected from this study correlates with Foster et al. (2008) that began looking into exercise intensities when the TT responses during incremental exercise are applied to steady-state training. The findings concluded that due to the delay in physiological responses during exercise tests, applying a reduced workload to a steady-state exercise must be employed. In 2009, Foster et al. began to translate submaximal exercise test responses into an exercise prescription for sedentary individuals. Their results reinforced the concept that prescribing exercise based on objective results requires downward translation (Foster, et al. 2009). The downward translation has a somewhat variable offset, ranging from the LP stage in well-trained individuals (Woltmann et al.

2015), to the LP-1 stage in untrained individuals (Foster et al. 2009) to the LP-1 or LP-2 stages in patients in rehabilitation programs (Lyon et al. 2014). This would correspond to the EQTT and the LP-TT being slightly lower than the VT in athletes. This finding reinforces the prescribed exercise based on the downward translation.

In 2012, (Mezzani et al.) an aerobic exercise intensity assessment and prescription for cardiac rehabilitation demonstrated an initial lag of the VO_2 response during incremental exercise shifts the VO_2 versus work rate relationship rightward with respect to a constant work-rate test. Therefore, for a given VO_2 value, the VT and RCT will be reached at a lower work rate (approximately 10%) when exercising at a constant work rate compared to incremental (Mezzani et al. 2012). This is consistent with our findings as well and validates this concept with not only exercise prescription for cardiac rehabilitation patients but for athletes as well.

Conclusion

In summary, the present study has compared the TT as a surrogate of the VT and RCT as a strategy for controlling intensity in well-trained athletes. The results support our hypothesis that when determining training intensity, the NEG TT stage is above the RCT. The results suggest the VT is slightly higher than the EQTT and the LPTT. We interpret this data as suggested that the TT may be used as a simple and non-invasive method to determining intensity for well-trained athletes.

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APPENDIX A

PAR-Q

Physical Activity Readiness Questionnaire - PAR-Q (revised 2002)

PAR-Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES	NO	
☐	☐	**1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?**
☐	☐	**2. Do you feel pain in your chest when you do physical activity?**
☐	☐	**3. In the past month, have you had chest pain when you were not doing physical activity?**
☐	☐	**4. Do you lose your balance because of dizziness or do you ever lose consciousness?**
☐	☐	**5. Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?**
☐	☐	**6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?**
☐	☐	**7. Do you know of any other reason why you should not do physical activity?**

If you answered

YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

DELAY BECOMING MUCH MORE ACTIVE:

- if you are not feeling well because of a temporary illness such as a cold or a fever – wait until you feel better; or
- if you are or may be pregnant – talk to your doctor before you start becoming more active.

PLEASE NOTE: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed Use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

NAME ________________________________

SIGNATURE ________________________________ DATE ________________

SIGNATURE OF PARENT ________________________________ WITNESS ________________
or GUARDIAN (for participants under the age of majority)

Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.

1:12

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APPENDIX B

INFORMED CONSENT

INFORMED CONSENT

Comparative Intensity Effectiveness on the Talk Test and Respiratory Compensation Threshold and Maximal Lactate Steady State

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Purpose and Procedure

This study is designed to evaluate the comparative effects of the Talk Test (TT) and the Respiratory Compensation Threshold (RCT) and Maximal Lactate Steady State (MLSS) in athletes in order to design a protocol that can be utilized in athletic populations to prescribe adequate exercise intensities for training purposes.
My participation will involve two pre-test incremental maximal cycle ergometer tests (same protocol, each requiring <60 minutes per test), and 3-5 post-test aerobic steady state tests (< 45 minutes/per test). The testing may be very fatiguing.
Testing will take place in the Human Performance Laboratory, Mitchell Hall 225.
During Pre-Test I, I will wear a snorkel-like device to analyze my breathing and, in order to measure my heart rate, I will have a heart rate monitor strapped to my chest. In Pre-test II, I will wear a heart rate monitor and be asked to recite a phrase that is given to me repeatedly. I recognize that I will be donating small blood samples, from my finger-tip, during the post-testing procedure. Throughout all of these testing procedures (pre and post) I will provide honest perceived exertion on how I am feeling when asked at each incremental stage, and will give my best effort.
I acknowledge participating in this study is voluntary and I have the right to quit at any time. If I have questions about this consent form or any of the procedures, I will not hesitate to ask questions.

Potential Risk

Similar to any form of exercise, I acknowledge I may get tired and my muscles may get sore. As a result, I understand this may change my training outside of the laboratory. Individuals trained in CPR, Advanced Cardiac Life Support and First Aid will be in the laboratory, and the test will be terminated if complications occur.
The risk of serious or life-threatening complications, for healthy individuals, like myself, is near zero.

Rights and Confidentiality

My participation is voluntary. I can withdraw or refuse to answer any questions without consequences at any time.
I can withdraw from the study at any time, for any reason, without penalty.
The results of this study may be published in the scientific literature or presented at professional meetings using grouped data only.
All information will be kept confidential through the use of number codes. My data will not be linked with personally identifiable information.

Possible Benefits
The primary benefit of this study is to the exercise community, and to the ability of exercise professionals to better serve their clients and athletes. By participating in a research project, I may find that my academic experience at UWL is richer and I may know more about my physical fitness level.
Questions regarding study procedure may be directed to Sarah Smith (906) 290-2170 smith.sarah3@uwlax.edu, Danielle Kolman (608) 604-0057 kolman.daniell@uwlax.edu, or their advisor (Dr. Carl Foster, 608-785-8687). Questions regarding the protected human subjects may be addressed to the UW-La Crosse Institutional Review Board for the Protection of Human Subjects (608-785-8124).
By signing blow, I agree to these terms and wholly understand my rights as a subject.

***You will not be penalized or treated differently for not participating in this study.**

Participant____ Date__________

Researcher____ Date__________

APPENDIX C

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Throughout the past few decades scientist have done numerous studies to establish the health benefits of exercise within the human population. Unfortunately, what is still unknown is the appropriate individual exercise prescription. Based on experimental testing, traditional exercise testing has been based on relative percentages of maximal exercise test (ACSM, 2010). Incremental exercise testing with respiratory gas analysis was the reference technique for determining exercise capacity, which was the measurement of maximal heart rate (HR_{max}), heart rate reserve (HRR), oxygen uptake (VO_{2max}), percent oxygen uptake ($\%VO_{2max}$), peak power uptake (PPO), ventilatory threshold (VT), respiratory compensation threshold (RCT) and maximal lactate steady state (MLSS) (ACSM, 2010; Mezzani et al. 2012; Katch et al. 1979; Scharhag-Rosenberger, 2009). Unfortunately, the tests can only be used on specific populations. Lack of resources and the ability of trained professionals are problems and make routine exercise testing impractical due to the cost and technological sophistication to conduct a maximal exercise test. This has dictated that using this method to determine exercise prescription intensity is inadequate and impractical.

The American College of Sports Medicine (ACSM) in 2010 has published exercise guidelines for both general and clinical populations. Based on the F.I.T.T. principle, exercise prescription is represented by frequency, intensity, time and type of exercise. While exercising frequency, time and type of exercise are intuitively comprehensible, there is confusion associated with intensity; in general, athletic, and clinically vulnerable populations.

A study conducted by Katch, Weltman, Sady, & Freeson (1978) recognized the impact of individual responsiveness and the relative weakness of the "relative percent concept(s)". Mezzani et al. (2012) suggested that threshold concepts may solve some of the maximal effort dependent weaknesses of the relative percent concept. However, there still are many practical difficulties with testing. Scharhag-Rosenberger (2009) reinforced this concept by testing the metabolic responses of prolonged exercise at fixed VO_{2max} percentages. After testing 21 healthy male subjects, by keeping the intensity constant, the results showed that prolonged exercise at given percentages of VO_{2max} lead to non-homogeneous metabolic strain, therefore, showing that intensity prescription for training and study purposes should not be solely based on the relative percent concept. This has led to the popularization of using subjective methods to measure exercise intensity.

The Rating of Perceived Exertion Scale (RPE) (Borg, 1998) is the main subjective method that is widely accepted in exercise physiology, particularly in cardiac rehab programs (cf. Eston, 2012). An alternative subjective method to RPE that has gained popularity, but has remained less well accepted, is the Talk Test (TT).

The origin of the TT began in 1937 when Professor Henry Joseph Grayson gave advice to British mountaineers to "climb no faster than you can speak" (Goode, Mertens, Shaiman, & Mertens, 1998). Later on, Goode et al. (1998) conducted a study suggesting if you can hear yourself breathing during exercise, you are exercising the limit at appropriate levels. Male subjects participated in three, separate tests on a leg ergometer.

The workload was increased by 25 Watts at 60-second intervals. As soon as the subject could "hear their breathing," they were instructed to keep pedaling with no change in resistance for 5-minutes. Heart rate was monitored and recorded. Days later, the same procedure was repeated amongst the same subjects but during running. Both tests resulted in the same findings. Heart rate corresponded with intensities appropriate for training effects, 60-90% of maximal heart rate. Little did Goode et al. know, but Grayson's simple recommendation set the foundation for what may be a superior subjective method for measuring exercise intensity.

In 1991, the TT was included in the ACSM Guidelines for Exercise and Training volume 4, but did not gain acceptance compared to the Karvonean method, VO_{2max}, VT or techniques based on blood lactate (ACE Sponsored Research, 2012). Over time, however, a substantial body of evidence began to support the validity of the TT. As a result, the TT has emerged as a viable method and a standard TT protocol has evolved (Brawner et al. 2006; Cannon et al. 2004; Dehart-Beverly, Foster, Porcari, Fater, & Mikat, 2000; Foster et al. 2008; Foster et al. 2012; Rodriguez-Marroya, J.A., Villa, G., Garia-Lopez, J.G., & Foster, C. 2012; Voelker et al. 2001; Loose et al. 2012; Norman, Kracl, Parker, & Richter, 2002; Norman, Hopkins, & Crapo, 2008; Zanettini et al. 2013).

The standard TT protocol is simple and easy to follow. A subject performs an incremental exercise, with stages lasting two to three minutes. After the completion of each stage, the subject uses a standard speech-provoking stimulus and is asked, "Can you speak comfortably?" Only three results can be achieved; speech is still comfortable equals a positive TT, speech is possible but not entirely comfortable equals' equivocal test (EQ), and a negative (NEG) test when comfortable speech is definitely not possible.

To achieve a positive TT, the subject must be able to speak comfortably while exercising. If the subject is hesitant in speaking comfortably, this results in an EQ TT. If the subject cannot speak comfortably, this results in a NEG TT. Different protocols have been used in studies conducting the TT, but the two most common are: 1) having the subject read a standard paragraph during the last thirty seconds of the stage, (the Pledge of Allegiance (POA) or the Rainbow Passage), or 2) having the subject listen to a previously recorded interview and respond to the questions out loud. Therefore, when the subject is asked if they can speak comfortably they can respond in one of three ways: 1) "yes," indicating a positive test, 2) "yes, but not sure," indicating an EQ test, or 3) "no," indicating a NEG test.

The TT has also been shown to be well correlated with the principles of speech production. In 2002, Meckel et al. examined the cardiopulmonary and metabolic responses to speech during exercise of varying intensities in healthy, young men. They found that to allow adequate speech production, one must adapt their breathing patterns to allow them to inhale required amounts of oxygen. During exercise, VO_2 and VCO_2 decrease during speech with a significant decrease in a significant decrease in overall ventilation. Specifically, in Meckel's study, the decrease in VO_2 and VCO2 during speech while exercising was accompanied by a significant drop in ventilation as well as an increase in blood lactate concentration ([HLa]).

With this information, observations about the breathing frequencies were also considered as being linked to the VT and RCT. During exercise at higher intensities, the increase in the natural breathing frequency conflicts with the need to suppress breathing frequency during speech. Thus, speech production becomes more difficult. This concept has led researchers to believe the TT may be highly correlated to the VT. Dehart-Beverley et al. (2000) demonstrated that the TT is a measure of VT in healthy adults. Results from this study suggested if subjects were unable to speak comfortably they were at or above their VT. Similarly, the relationship between the TT and the VT was also seen in well-trained cyclists (Recalde et al. 2004; Rodriquez-Marroyo, Villa, Garcia-Lopez, & Foster, 2012), patients with coronary artery disease (Brawner et al., 2006; Volker, 2001), sedentary individuals (Foster et al., 2009) and patients with recent myocardial revascularization (Zanettini et al., 2013). Foster et al. (2008) tested the validity of the TT by manipulating the VT and has shown the TT to be a reliable marker of intensity. As a result of all this promising information, it is recommended that exercising below VT, and the TT may be a suitable method for prescribing exercise intensity (Mezzini et al 2012).

Persinger et al. in 2004, studied the consistency of the TT being linked to the VT on different modes of exercise. Sixteen healthy and active subjects performed four exercise tests, two treadmill and two cycle ergometer tests. The results illustrated the VT for both the treadmill and cycle ergometer were similar by means of the TT. The study also concluded the last positive (LP) and EQ stages are within the ACSM intensity guidelines while the NEG stage exceeded the recommendations.

Besides the TT being related to the VT, research has identified that it may also be related to the lactate threshold (LT). Quinn & Coons (2011) identified differences between measured physiological and perceptual variables at the VT and LT. The results revealed during the positive stage of the TT, subjects were below their LT and during the EQ and NEG stages of TT, subjects were above their LT. Quinn & Coons (2011) also discovered two other important findings. First, the physiological and perceptual values during the LP stage of the TT were significantly lower than physiological and perceptual values recorded at the LT. Secondly, the physiological and perceptual values during the EQ and NEG TT stages were significantly higher than the physiological and perceptual values at the LT. This study concluded that in response to the TT, VT and LT produce similar effects during the positive, EQ and NEG stages. In short, the TT is a valid surrogate method of both physiological markers.

So far, research has confirmed the validity and reliability of the TT by standardizing a simple protocol and has identified the TT may be robustly related to the VT and LT. Simultaneously, the TT has also been evaluated to ensure its consistency and ability to be used amongst clinical, sedentary and active populations. In 2004, Cannon and colleagues demonstrated that the TT was an appropriate tool for avoiding ischemia in clinical populations. Other variables, such as exercise time, heart rate (HR) and RPE, were significantly lower during the LP stage of the TT than the acute onset of electrocardiographic evidence of ischemia. The major finding of this study indicated that the TT preceded the ischemic threshold and produced HR's 10 beats below the onset of ischemic symptoms. Therefore, when a cardiac patient is able to speak comfortably, they are unlikely to have exertional ischemia.

Brawner et al. (2006), focused on studying the ability to use the TT with clinical patients suffering from Coronary Artery Disease (CAD). Twenty-four patients completed one maximal and two sub-maximal exercise tests. The two sub-maximal tests were both TT's with one being completed on a treadmill and the other on an indoor track. The protocol followed stages of the maximal test, while the subjects on the indoor track were instructed to walk/jog at the fastest pace that still allowed them to talk comfortably. The study revealed at the LP on the treadmill, 48% patients were above VT and at the EQ of the TT, and 89% of the patients were above VT. On the track, 62% of the patients were above VT and there were no significant differences between the two TT protocols. This data further supported the validity and consistency of the TT between different protocols.

Zanettini et al. (2012) validated the optimal level of training intensity in patients with recent myocardial revascularization. Fifty patients in phase II cardiac rehab underwent three TT's to evaluate the within-in patient and between-operators reliability in assessing the workload at TT thresholds. The data from a final cardiopulmonary exercise test were compared and the workload range between the patient's aerobic and anaerobic threshold was considered the optimal training zone at the LP of the TT.

Recalde and colleagues (2002) applied a similar approach to well-trained individuals. The positive stages of the TT were consistently below the VT and the first negative stage of the TT was almost at the RCT. These results are not only similar to the Dehart-Beverly et al. (2000) and Voelker et al. (2002), but they indicate the TT can also be applied as an exercise prescription method a wide range of populations.

With all these new findings about the TT, Foster et al. (2008) began evaluating what happened to exercise intensities when the TT responses are applied to steady-state training. His findings in 2008 concluded that due to the delay in physiological responses during an exercise test, applying a desired workload to a steady-state exercise bout must be reduced. Therefore, in 2009, Foster started to translate these submaximal exercise test responses into an exercise prescription for sedentary adults. It translated that to get appropriate HR, RPE and TT responses in sedentary individuals, exercise should be prescribed approximately one stage below the LP stage at TT. Foster significantly reinforced that prescribing exercise based on objective results is inaccurate (Foster et al. 2009).

Jeans et al. (2011) conducted a study evaluating how much of a reduction in absolute exercise intensity was needed to allow comfortable speech in well-trained individuals. Her results showed that for well-trained populations, absolute exercise intensity should be reduced to that of the LP-1 and LP stages. In order to validate Jeans et al. (2011) results, Foster and colleagues conducted a study evaluating the ability of TT responses during an exercise test to guide exercise testing in competitive runners. Steady-state conditions were observed at the absolute intensity associated with LP stage of the TT. However, absolute intensities at the EQ stage of the TT produced results exceeded steady-state conditions. In 2011, Jean and colleagues previous study agreed with these results, but differed from Foster's results in that steady-state conditions were observed at the LP stage rather than the LP-1 stage (Foster et al. 2012).

Parfitt, Evans, & Eston (2012) conducted a study that applied Foster and colleagues (2012) steady-state results one step further. They evaluated if subjective measurements of RPE had the ability to be 'clamped' in order to control exercise intensity. In this study, they measured the ability of a Perceptually Regulated Training (PRET) clamped at the RPE of 13 to improve aerobic fitness and cardiovascular health. Using a randomized study, sedentary volunteers were recruited and assigned to a training group or a control group. All subjects completed at maximal incremental exercise test to measure $VO2_{max}$. Following that test, the training group completed a program with the intensity clamped at an RPE of 13 three times a week for eight weeks while the control group completed no training at all. Results revealed that fitness and improved significantly improved in the training group. Specifically, having a RPE program clamped at an RPE of 13 yielded improvements in VO_{2max}, mean arterial pressure (MAP), total cholesterol, and body mass index (BMI). Subjects in the training group also reported they felt "pleasant" while working at an RPE of 13. On the other hand, in the control group overall fitness and health significantly declined.

This previous study was particularly important to Woltmann's (2013) study and our current study because it suggested that if exercise is clamped at an RPE of 13 it will produce: 1) physiological responses within ACSM's guidelines and 2) improvements in overall fitness and cardiovascular health. By being at an RPE of 13, it is approximately the same as the intensity perceived at the LP stage of the TT. Therefore, improvement in overall fitness and health should occur and fit within the ACSM's guidelines if the exercise intensity if clamped to that of the intensity of the LP stage.

Woltmann (2013) examined what happened to the exercise intensity, HR and [HLa] when the exercise condition defined by the TT was held constant. Previous literature concluded the LP-1 and LP stages generally produced intensities compatible with accepted training intensity for healthy adults, while the EQ and NEG stages produced intensities compatible with training in athletes. Therefore, she wanted to identify if the EQ and NEG stages could be produced in different populations rather than solely athletes. She recruited apparently healthy students from the University of Wisconsin-La Crosse and had them perform two incremental exercise tests on a motorized treadmill: 1) to measure respiratory gas exchange values (VT, RCT, and $VO2_{max}$) and, 2) a TT protocol with no gas exchange. On separate days, Woltmann had the subjects perform four 30-minute treadmill runs until exhaustion with instructions to maintain either: 1) a positive TT (represented by both LP and Lp-1), 2) an EQ TT, or 3) a NEG TT. Speed, HR, RRE and TT responses were recorded during the last 30 seconds of each 2-minute stage of the 30-minute run and [HLa] samples were recorded throughout the testing procedure. Steady-state conditions were achieved in the LP-1 and LP stages. All six of the measured values (speed, HR, RPE, [HLa], %HRR, and TT responses) remained relatively constant across the 30-minute time trial. In addition, all of the subjects successfully completed the 30 minutes in both the LP-1 and LP runs, and the [HLa] remained relatively constant across the 30 minutes. However, steady-state conditions were not achieved during the EQ and NEG stages because not all subjects were able to successfully complete the 30 minutes. Woltmann's results support that the TT can be used proactively to control exercise intensity below the LT and maximal lactate steady state (MLSS) in well-trained adults.

With research conducted so far, it is safe to conclude that: 1) exercise intensity can be prescribed using the TT, 2) the TT is a valid method of measuring physiological markers such as the VT and the LT and, 3) the TT is an appropriate method of measuring exercise intensity in healthy, sedentary, clinical and athletic populations. However, even though Woltmann (2012) was able to identify what physiological effects occur when the exercise conditions are held constant, she was unable to establish the MLSS because only a few of subjects were able to complete the NEG stage and she only conducted one NEG stage trial. Therefore, we are aiming to find with our study if the exercise condition defined by the TT is held constant, will it be able to control exercise intensity below the LT or MLSS.

By completing our proposed study, we hope to find when the TT is negative it is approximate to the RCT. With our results, we also hope to implement training methods and intensities for coaches and athletes using the TT method approach with physiological marker points.

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