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TALK TEST VS. HEART RATE RESERVE: IS THERE A SIMILAR TRAINING EFFECT?

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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HEART RATE RESERVE VERSUS TALK TEST: IS THERE A SIMILAR TRAINING EFFECT?

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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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The purpose of this study was to determine if sedentary individuals, categorized by American College of Sports Medicine (ACSM) guidelines, would have a training effect from the use of the talk test or heart rate reserve to monitor exercise intensity. This study tested 54 previously inactive, young adults who, regardless of group, completed three components. Subjects were randomized into either the Talk Test (TT) group or the Heart Rate Reserve (HRR) group. First, a pre maximal oxygen consumption (VO_2max) test were completed. Second, over the course of 10 weeks, the subjects participated in three, 40 minute training sessions per week, each consisting of a five minute warm up, 30 minute training, and five minute cool down. Workload, RPE, and heart rate (HR) were recorded within the 30 minute training session for both groups. Additionally, the TT group was asked "Can you speak comfortably?" in which a score of "yes" (+), "yes, but" (+/-), or "no" (-) was recorded. Third, a post VO_2max test was completed to compare to pre scores. This study supports the hypothesis that sedentary individuals can use the TT as a simple and cost effective alternative to self-monitor exercise intensity levels while remaining within ACSM intensity guidelines.

ACKNOWLEGEMENTS

I would first and foremost like to extend an enormous thank you to my co-thesis partners Anna Wargowsky, Jillian Turek, and Samantha Suckow. Without all of their time and efforts I would never have been able to complete such a complex study on my own. Likewise, we had about 51 additional volunteers who helped trained the subjects for just over a combined 900 hours! Additionally, we arguably had the best group of subjects who were very dedicated to finishing all 30 sessions and were such a great group of people to get to know. To those subjects in the Talk Test group, thank you for reciting the Rainbow Passage 184 times, each, to aid in our data collection!

A huge thank you to my family and friends who have supported me through this rewarding, yet challenging experience. I received an endless amount of support from those who are closest to me and I could not have done it without you. A special thanks to my fiancé, Nick Wiese, who supported me every second of the day even though most days I was gone from 4:00am-8:00pm. Your love and support has meant to the world to me and I cannot wait to marry you!

Another couple of individuals I am endlessly thankful for are Maria Cress, Kim Radtke, and Chris Dodge. These three individuals are the type of people that despite the challenges I faced, were always able to put a smile on my face!

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INTRODUCTION

With progressive health concerns about sedentary behavior, the American Heart Association (AHA) and the American College of Sports Medicine (ACSM) combined to recently revise the physical activity (PA) recommendations in 2007 (Pescatello, Areana, Riebe, & Thompson, 2014 & American Heart Association, 2015). The guidelines provided are based on Frequency (how often), Intensity (how hard), Time (how long), Type (what kind), Volume (how much) and Progression (change of all factors over time), known as the FITT-VP principle. Individuals generally understand the concise details of the FITT-VP principle, except the variability that lies within the intensity marker.

The recommendations set by AHA and ACSM suggest that healthy adults aged 18-65 participate in a minimum of 30 minutes of moderate activity at least 5 days a week or vigorous aerobic activity at least 20 minutes at least 3 times per week. Otherwise, the recommendations encourage accumulating at least 150 minutes of moderate intensity PA per week or 75 minutes of vigorous intensity PA per week. For healthy adults aged 18-65, recommendations also include engaging in muscular strength and endurance activity to promote metabolic function and cardiovascular fitness. The dose-response relationship between PA and health indicate an individual can reduce risk of chronic disease, weight gain, and disabilities while improving overall physical health and fitness (Pescatello et al., 2014). So what can define what is considered low, moderate, or high intensity exercise?

Widely considered the gold standard measurement of exercise, a maximal exercise test for any individual can determine maximal oxygen uptake (VO2max), maximal heart rate (HRmax), ventilatory threshold (VT), heart rate reserve (HRR), metabolic equivalents (METs), and Rating of Perceived Exertion (RPE). From these measurements, markers of intensity such as percent maximal oxygen consumption (%VO2max), percent oxygen consumption reserve (%VO2R), percent metabolic equivalents (%METs), percent heart rate max (%HRmax), percent heart rate reserve (%HRR), and again VT and RPE (Pescatello et al., 2014). Although these methods are preferred to determine exercise intensity, they are not always readily available and understood by the general population. Thus, another respected subjective measure of exercise intensity is known as the Talk Test (TT). The TT is a subjective measure of exercise intensity in which it is measured on comfort of speech based on the VT (Dehart-Beverly, Foster, Porcari, Fater, & Mikat, 2000).

Given the expense, time, and effort needed for gold standard measurements, the TT has been accepted as a more practical alternative of exercise intensity in the general population. In order to create sound, air must be expelled from the lungs to initiate vocal cord activity. Given the TT is a natural indicator of increased breathing frequency and decreased comfort of speech, it has been found to be a useful measure of exercise testing and intensity prescription (Dehart-Beverly et al., 2000; Doust & Patrick, 1981; Foster et al., 2009; Goode, Mertens, Shaiman & Mertens, 1998; Woltmann et al. 2015; Brawner et al., 2006). Although he did not know the science behind it at the time, in 1939 Professor Grayson suggested to British mountaineers to "climb no faster than you can talk"; indicating suggested activity at or around the TT, an accepted surrogate of the VT

(Dehart-Beverley et al., 2000; Foster et al., 2008; Foster et al., 2009; & Recalde et al., 2002). Looking at more recent research regarding the TT, Goode et al. (1998) indicated that exercising at a level where subjects could "hear their breathing" was at or near the VT.

The validity of the TT, as a surrogate of the VT, has been demonstrated in a wide variety of populations categorized on age, activity level, and those with any form of coronary artery disease (CAD) (Bawner et al., 2006; Dehart-Beerley et al., 2000; Foster et al., 2008; Foster et al. 2009; Lyon et al., 2014; Recalde et al., 2002; Voelker et al., 2001). Despite categorized populations, stages of the TT remain the same. The Last Positive (LP or +), Equivocal (EQ or +/-), and first Negative (NEG or -) stages indicate the relationship of breathing frequency and comfort of speech production at or around the VT. When asked "Can you speak comfortably?" the LP indicates the highest stage at which the subject can speak comfortably during exercise; the EQ indicates the subject can speak, but not comfortably; and the NEG indicates the first stage at which speech production while exercising is definitely not comfortable (Woltmann et al., 2015). Recently, Woltmann et al. (2015) explored the physiological impact of "clamping" or adjusting exercise prescription based on the TT stages.

The need for the TT as a subjective form of exercise prescription is based on the variability of measured and calculated HRmax for individuals of any age, sex, health status, and PA level. Dating back to 1938, the formula 220-age to predict HRmax for any individual has no history of direct publication but is based on Sid Robinson's observation of a best fit line (Robergs & Landwehr, 2002). Ultimately, across the population, HRmax does not take into account for those on medications, nor does it account for the older

population who are physically fit and the young individuals who are not; over or underestimating HRmax, respectively. The only gold standard way of determining HRmax is from a maximal exercise test in which VO2max and HRmax can be determined and thus, the %HRmax, or %HRR, can be used for exercise prescription. The purpose of this study was to compare the training effect of an exercise training program controlled by %HRR training based on ACSM's guidelines compared to one using the TT training (just below VT). We hypothesized that sedentary individuals who trained in the Talk Test group would demonstrate a similar training effect to that experienced by a group using %HRR according to ACSM guidelines (Pescatello et al., 2014).

METHODS

Subjects

Fifty-four healthy, previously inactive, young adults were recruited from the University of Wisconsin-La Crosse (UWL) community. All subjects completed the Physical Activity Readiness Questionnaire (PAR-Q) and an Exercise History Questionnaire to determine if any contradictions or physical limitations affecting their ability to participate in the study were present. Prior to testing, all subjects were given both oral and written versions at the research protocol. The purpose, and potential risks and benefits were explained before they provided written informed consent. The UWL Institutional Review Board for the Protection of Human Subjects reviewed and approved the protocol.

Subjects achieving a relative VO_2max over 50 ml/kg/min or 43 ml/kg/min for males and females, respectively, were excluded from the study. Eight subjects were excluded from the study because of their aerobic capacity; thus, 46 subjects initially participated in the study. However, of the original 46 subjects, only 42 completed the training program. Descriptive statistics of the subjects who completed the study are presented in Table 1. Data analysis was based on the subjects who completed the study.

Table 1. Descriptive characteristics of subjects at beginning of study (mean ± SD).

	Talk Test (n=20)	Heart Rate Reserve (n=24)
Age (yrs)		
Males (17)	21.2 ± 2.82	21.0 ± 5.90
Females (27)	20.5 ± 1.97	19.5 ± 1.26
Height (cm)		
Males	179.5 ± 7.27	176.9 ± 3.97
Females	165.0 ± 9.84	166.0 ± 7.74
Weight (kg)		
Males	83.9 ± 10.63	77.0 ± 14.55
Females	67.6 ± 10.72	65.5 ± 11.80

Values presented represent mean ± standard deviation.

Protocol

Each subject performed pre and post training incremental maximal exercise tests on an electrically-braked cycle ergometer (Lode Excallibur, Groningen, The Netherlands). The workload began at 25 Watts (W) and increased by 25 W every two minutes up to maximal exertion. Subjects wore a scuba type mask to allow analysis of respiratory gas exchange using open circuit spirometry (AEI, Pittsburgh, Pennsylvania). Calibration was conducted using reference gases (16% O_2, 5% CO_2) and room air. The pneumotach was calibrated with a 3-liter syringe. Maximal oxygen consumption was defined as the highest continuous 30 seconds of VO_2 during the test. Ventilatory threshold was identified using a combination of the v-slope and ventilatory equivalent methods (Foster & Cotter, 2005). Heart rate was measured continuously using

radiotelemetry, and RPE was assessed using the 6-20 category ratio scale of Borg (Borg, 1998) at the end of each stage. Following the completion of the initial exercise tests, subjects were stratified by VO_2max within each gender and then randomly assigned to either the TT or HRR training groups.

The training program was 10 weeks in duration (three times weekly, 40 minutes per session). All training sessions were performed on a mechanically-braked cycle ergometer (Monarch, Stockholm, Sweden). The pedaling rate was fixed at 60 revolutions per minute (rpm) (reinforced by music with a dominant beat of 120 counts per minute). Thus, the power output (PO) was effectively regulated by changing the resistance on the pedals. All subjects wore a HR monitor during training.

Talk Test Group

The TT group trained solely using the TT as the intensity measure. All training sessions began with a 5 minute warmup at ~30 W. For the first exercise session, the initial workload was set at a PO corresponding to 90% of VT. After five minutes, subjects recited the Rainbow Passage and speech comfort was assessed. If the subject was able to speak comfortably, PO was increased by ~30 W. If comfortable speech was either EQ or NEG, PO was reduced by ~30 W. Although not used to determine training PO, %HRR and RPE (6-20 scale) were recorded at five minute intervals. A five minute cool down at ~30 W followed the 30 minute training session. Session RPE (0-10 scale) (sRPE) was recorded at the conclusion of the session. For all subsequent exercise sessions, PO for the initial five minutes after the warmup was set at the same PO where the subject could speak comfortably during the previous workout.

Heart Rate Reserve Group

The HRR group trained solely using HR as the intensity measure. All training sessions began with a five minute warmup at ~30 W. For the next 30 minutes, training intensity was set using %HRR ranges calculated from their pre testing maximal exercise test. The prescribed %HRR ranges were 40-59% for weeks 1-4, 50-69% for weeks 5-8, and 60-79% for weeks 9-10. Every 5 min HR was measured. If HR was below the target %HRR range, PO was increased ~30 W. If HR was within the %HRR range, PO remained the same. If HR was above the %HRR range, PO was reduced by ~30 W. A five minute cool down at ~30 W followed the 30 minute training session. Although not used to determine training intensity, RPE (6-20 scale) was recorded at 5 minute intervals and sRPE (0-10 scale) was recorded at the conclusion of the session.

Exercise enjoyment was assessed during one session each week. Enjoyment was assessed using the Exercise Enjoyment Scale (Stanley & Cumming, 2010). This was given to the subjects before exercise, 15 minutes into the exercise bout, and at the conclusion of the 5 minute cool down.

Statistical Analysis

Standard descriptive statistics were used to describe subject population and to summarize differences from pre and post testing: Independent t-tests were used to compare pre-testing scores between the HRR and TT groups. If there was no significant difference in pre-testing scores between groups, changes from pre to post testing were compared using two-way ANOVA with repeated measures. If the pre-testing scores were significantly different between the HRR and TT groups, changes from pre to post testing were compared using analysis of covariance. If there was a significant F ratio, Tukey's

post-hoc tests were used to isolate pairwise differences. Alpha was set a .05 to achieve statistical significance.

RESULTS

The %HRR, RPE, sRPE, and PO were examined to see if each, fell within the ACSM recommended intensity ranges. In Figure 1, comparison of training HR between the TT and HRR groups were compared where all HR values were averaged within each individuals' three weekly sessions and by group within weeks. Intentional change for progression at training intensity within the HRR group is indicated by the vertical dashed lines after four and eight weeks. Within the HRR group, measurement of HR after every five minutes was done to determine if the subject was below, within, or above the target %HRR window. If the subject was below the target %HRR, ~30 W was added for the next five minutes. If HR was above the target %HRR, ~30 W was taken off for the next observation. Individuals who achieved a HR within the target %HRR remained at the same workload. Given the progression in %HRR target windows and based on ACSM guidelines for the HRR group, Figure 2 indicates the assumed increase from weeks 1-4 to weeks 5-8, and that the HRR group even surpasses the TT group in weeks 9-10. Statistical significant differences between the two groups %HRR values are indicated with an asterisks in both Figure 1 and Figure 2 ($p<0.05$). The shaded box in both figures indicates the accepted ACSM ranges for %HRR in the specific population.

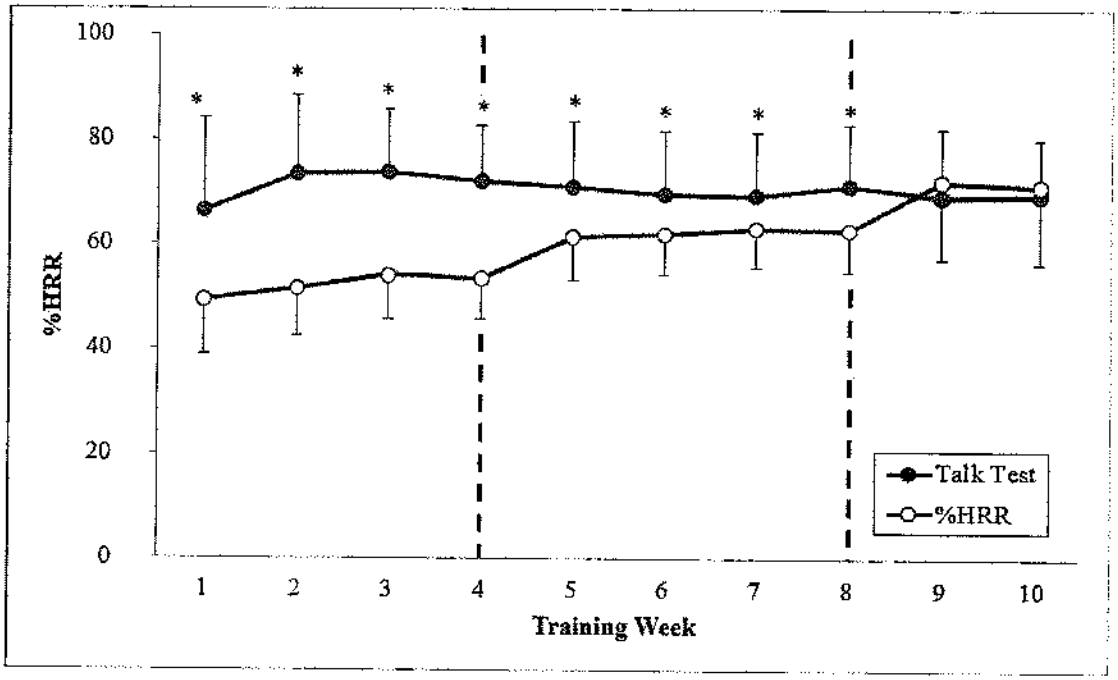

Figure 1. Comparison of average (±SD) training heart rate between the Talk Test and the HRR groups across weeks of training. Accepted ACSM ranges for %HRR are shaded.
*Significant difference between groups ($p<0.05$).

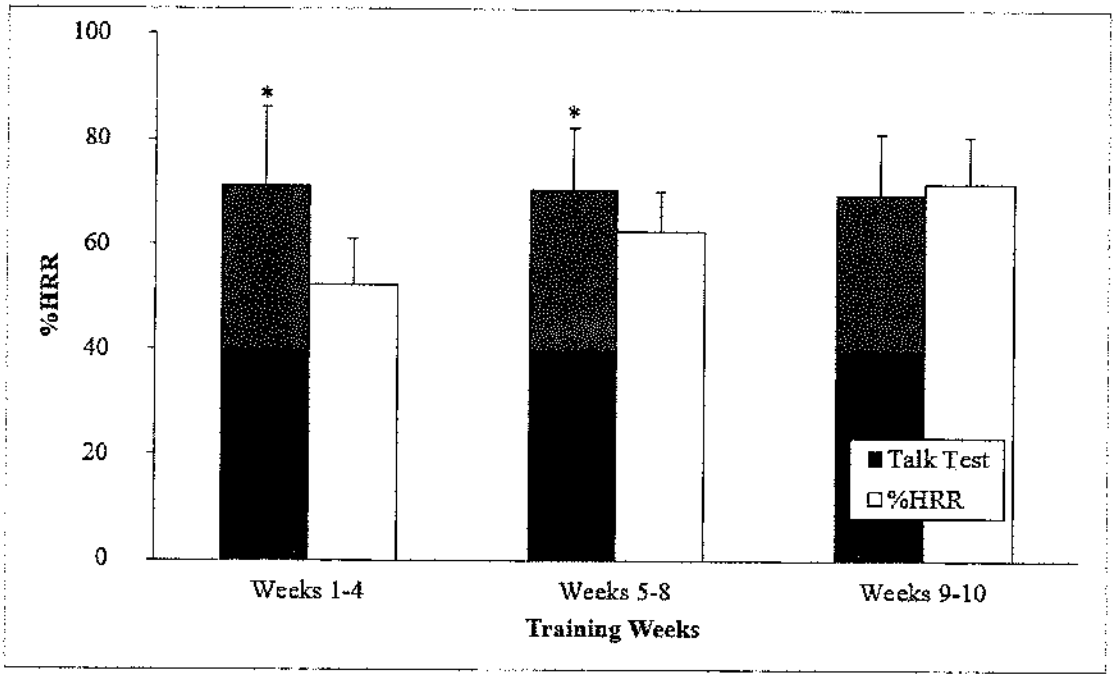

Figure 2. Comparison of average (±SD) training heart rate between the Talk Test and the HRR groups across grouped training weeks. Accepted ACSM ranges for %HRR are shaded.
*Significant difference between groups ($p<0.05$).

Throughout each individual 30 minute session, RPE was recorded every five minutes; regardless of group. In Figure 3, the gray box represents the ACSM recommended guidelines of 12-15 (6-20 scale), which is moderate to hard for sedentary individuals. The average of all the TT participants weekly training sessions remained within ACSM recommended RPE guidelines throughout the ten week training study. As indicated by asterisks, during weeks 1-4, Figure 3 and Figure 4 illustrate the TT group perceived the training significantly harder ($p<0.05$). Figure 3 contains vertical dashed lines at week four and eight indicating progression in %HRR ranges for HRR group, which is the manual progression pattern for training controlled by %HRR. Figure 4 shows gradual increases of RPE within the HRR group during intensity changes, whereas, the TT group remains near 13, or "somewhat hard".

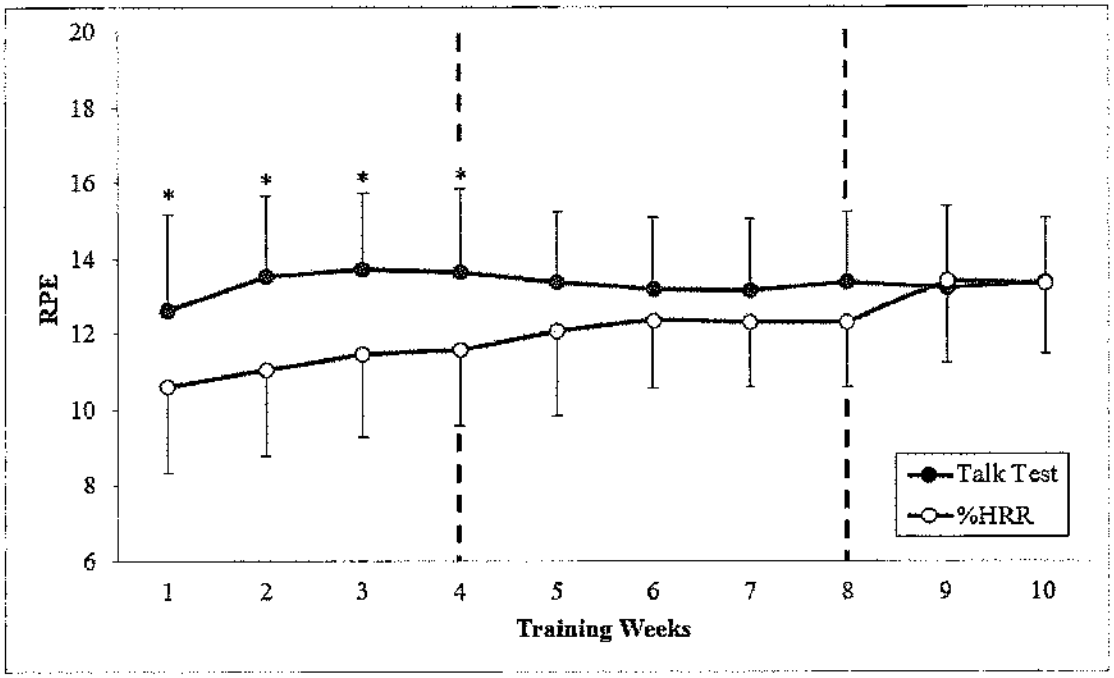

Figure 3. Comparison of average (±SD) RPE values between the Talk Test and the HRR groups across weeks of training. Accepted ACSM ranges for RPE are shaded.
*Significant difference between groups ($p<0.05$).

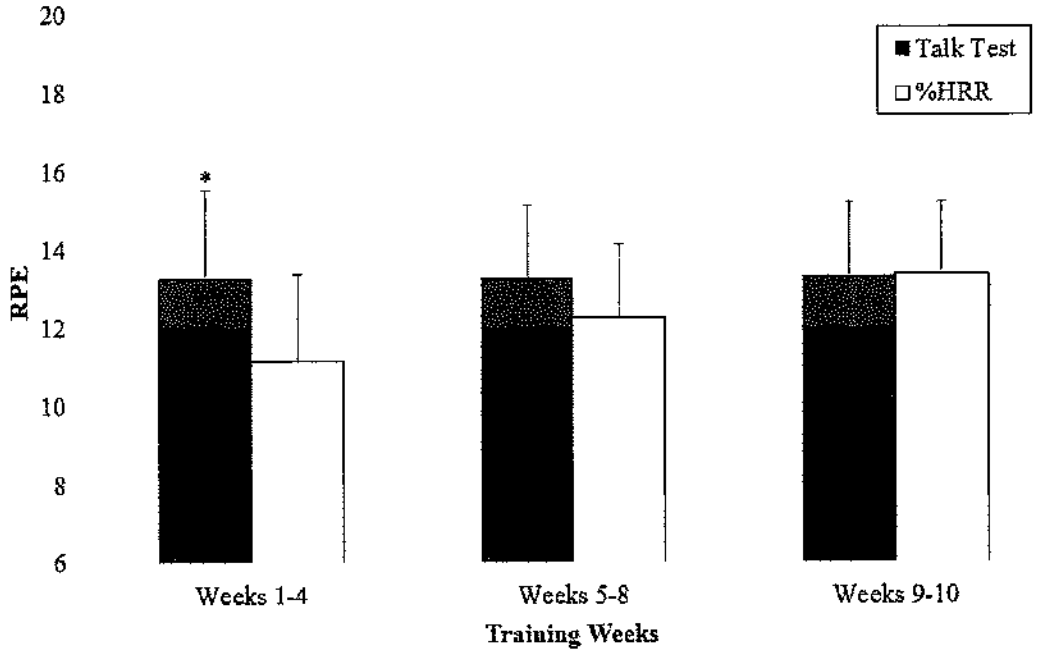

Figure 4. Comparison of average (±SD) RPE values between the Talk Test and the HRR groups across grouped training weeks. Accepted ACSM ranges for RPE are shaded.
*Significant difference between groups ($p<0.05$).

Just as RPE was recorded every five minutes within a 30 minute session, absolute PO was recorded and expressed as relative PO as W per kilogram. Revolutions per minute remained constant and workloads in both groups remained constant, increased or decreased by ~30 W after each five minute stage depending upon training protocol. Generally, PO for subjects in the HRR group did not need much change in workload per five minute observation period to remain within the %HRR window. The TT group, however, always increased in workload when at the LP or always decreased when at the EQ or NEG stage. Indicated by asterisks in Figure 5, during weeks 1-5 the TT group trained at significantly higher relative PO than the HRR group. As previously illustrated, vertical dashed lines at week four and eight indicate a change in %HRR ranges the HRR group trained within. Both Figure 5 and Figure 6 show that initially the TT group trained at higher workloads relative to body weight, but by weeks 9-10 both groups had similar PO.

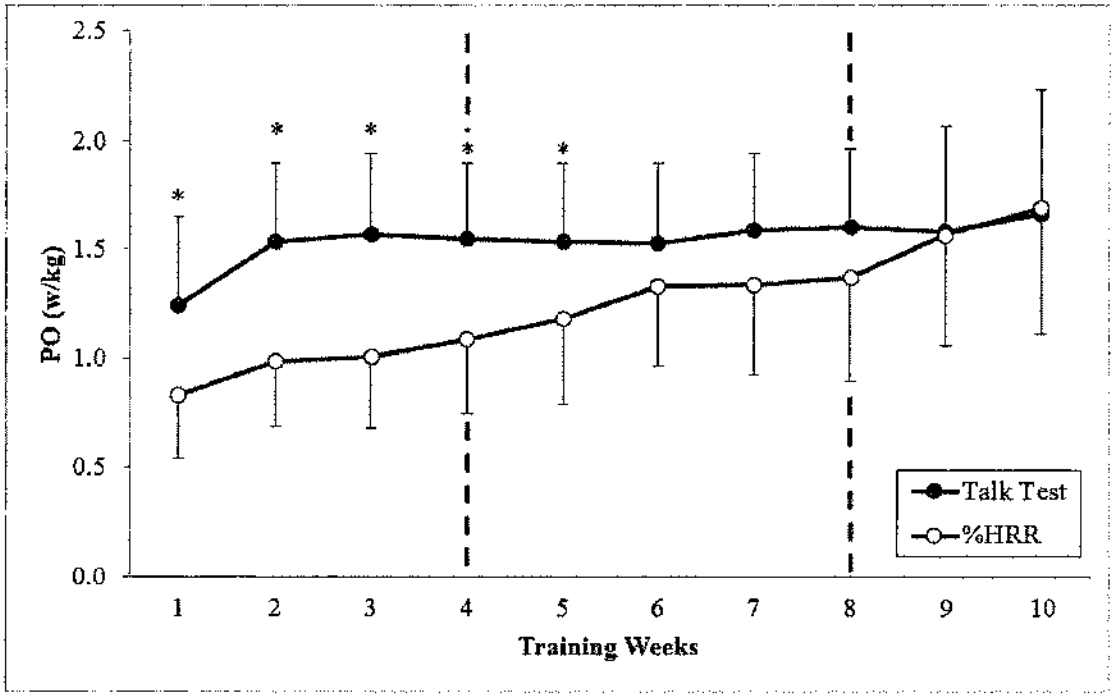

Figure 5. Comparison of average (±SD) PO values between the Talk Test and the HRR groups across weeks of training.
*Significant difference between groups ($p<0.05$).

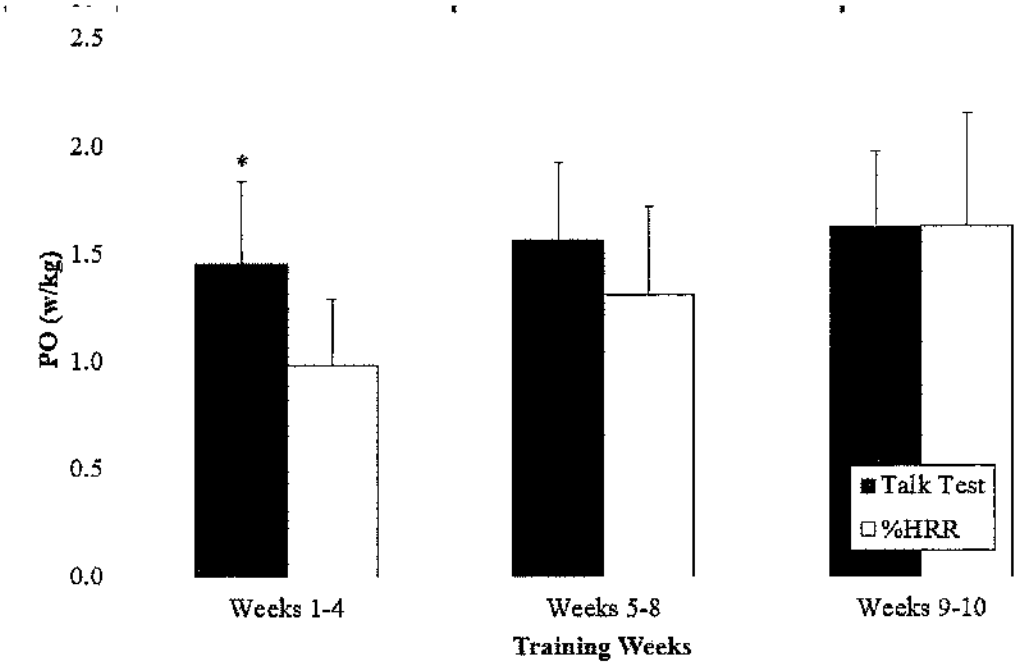

Figure 6. Comparison of average (±SD) PO values between the Talk Test and the HRR groups across grouped training weeks.
*Significant difference between groups ($p<0.05$).

An additional marker of overall intensity within a session was measured by sRPE using the 0-10 Borg scale. Figure 7 and Figure 8 indicate the average sRPE of the TT group remained within accepted guidelines of 3-5, "moderate" to "hard". Indicated by asterisks, the TT group perceived the overall training to be significantly harder than the HRR group in weeks 1-4. Vertical dashed lines at week four and eight indicate a change in %HRR ranges the HRR group trained within. As illustrated in Figure 8, the HRR group gradually perceived the training sessions harder than each previous %HRR training window and was he same as the TT group in weeks 5-10.

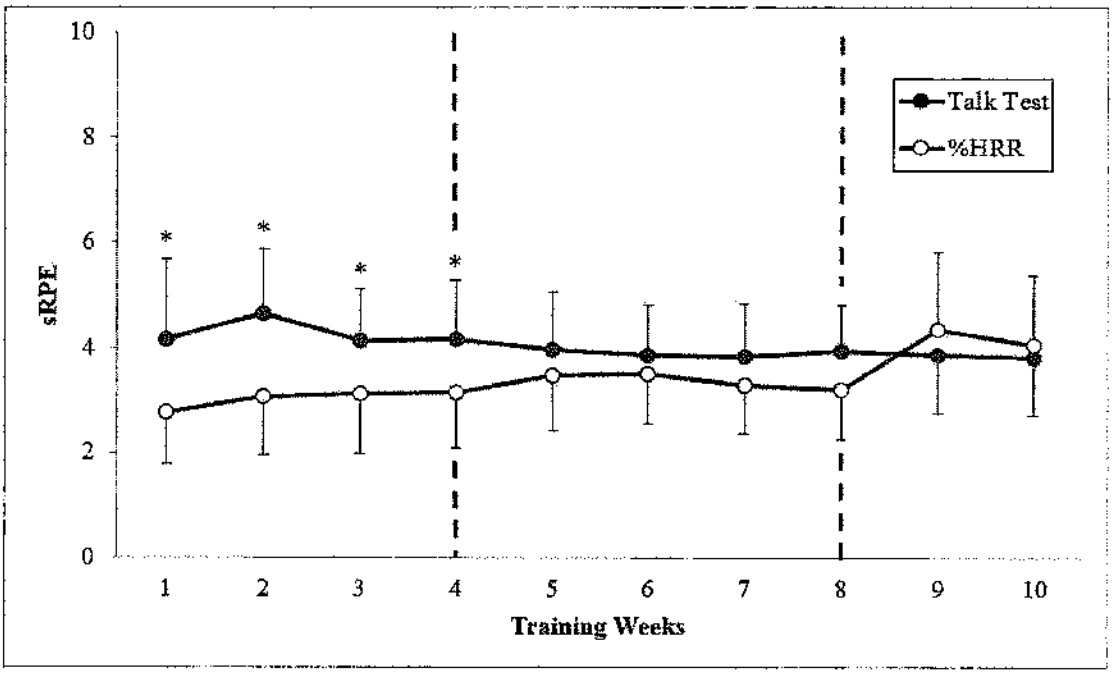

Figure 7. Comparison of average (±SD) sRPE values between the Talk Test and the HRR groups across weeks of training. Accepted ranges for sRPE are shaded.
*Significant difference between groups ($p<0.05$).

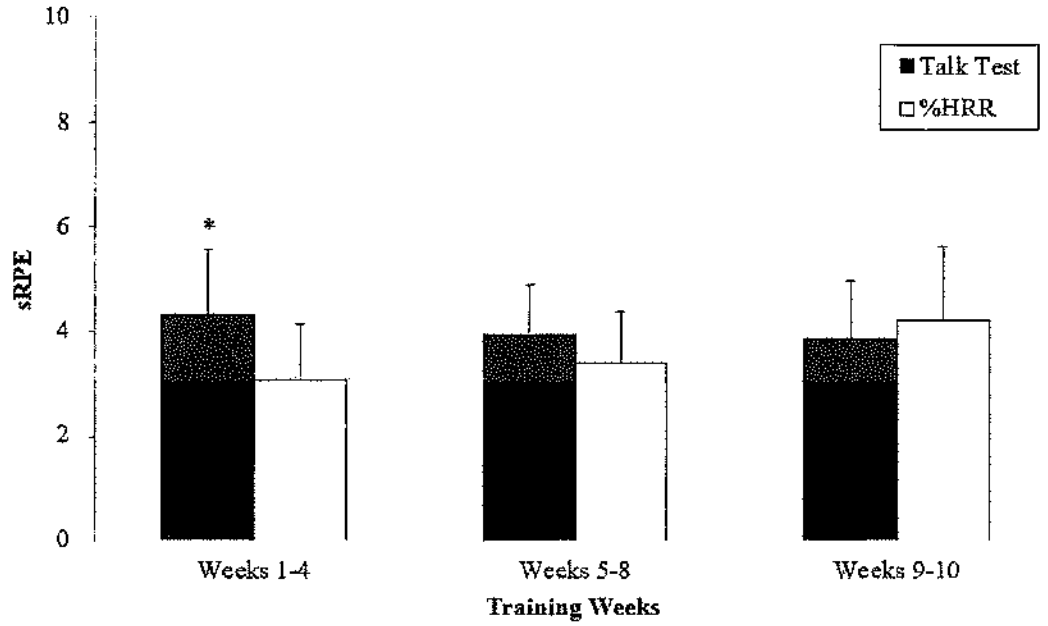

Figure 8. Comparison of average (±SD) sRPE values between the Talk Test and the HRR groups across grouped training weeks. Accepted ranges for sRPE are shaded.
*Significant difference between groups ($p<0.05$).

The comfort of speech production in the TT group was additionally observed every five minutes within the 30 minute training session. Illustrated by Figure 9, from weeks 1-10 the TT group perceived speech production between +, or LP, and +/-, or EQ. Given that the +/- is generally accepted as a surrogate of the VT, Figure 9 suggests that the TT subjects trained below the VT.

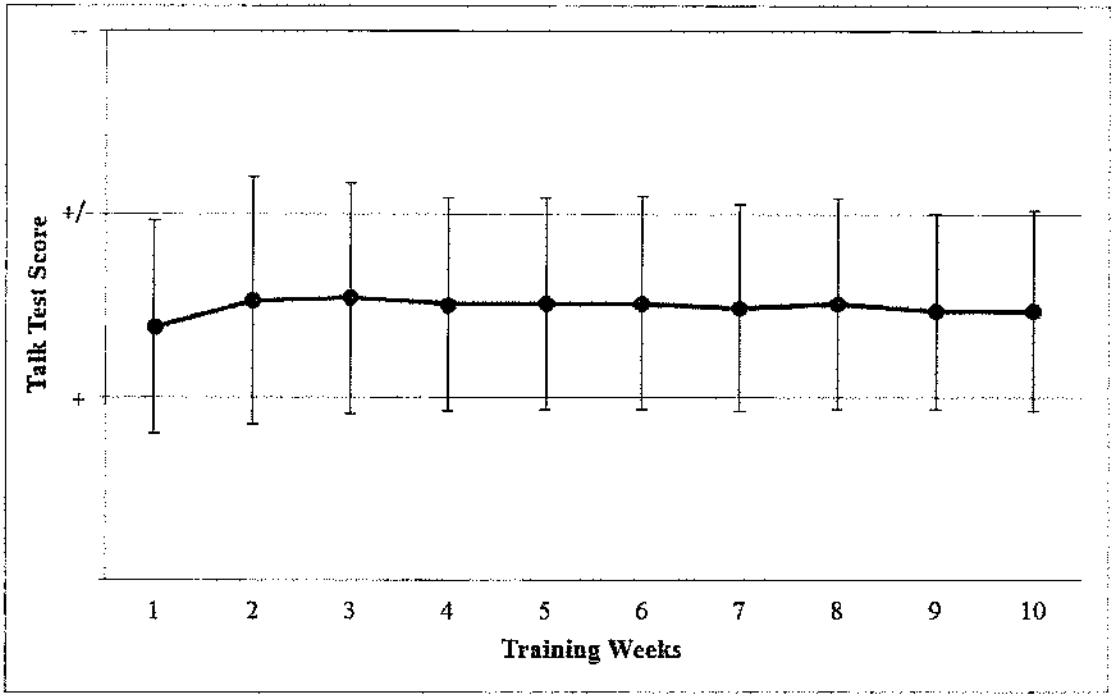

Figure 9. Talk Test Score average (±SD) within the Talk Test group across weeks of training. The +/-, or EQ, category is generally accepted as a surrogate of the ventilatory threshold.

The week by week responses of %HRR in relation to the %HRR at VT from the pre to post incremental tests are presented in Figure 10. Because the workload was regulated entirely by the TT response, the %HRR tracked significantly higher in the TT group than the HRR group in weeks 1-8, where %HRR was controlled at the low ranges recommended by ACSM (Pescatello et al., 2014) during the early weeks ($p<0.05$). During the last two weeks of training, with the HRR group controlled at the higher 60-80% of HRR recommended by ACSM, there was no differences in the %HRR values during training between the TT and HRR groups. There was a small increase in the %HRR at the VT during incremental exercise in both training groups. Vertical dashed lines at week four and eight indicate a change in %HRR ranges the HRR group trained within.

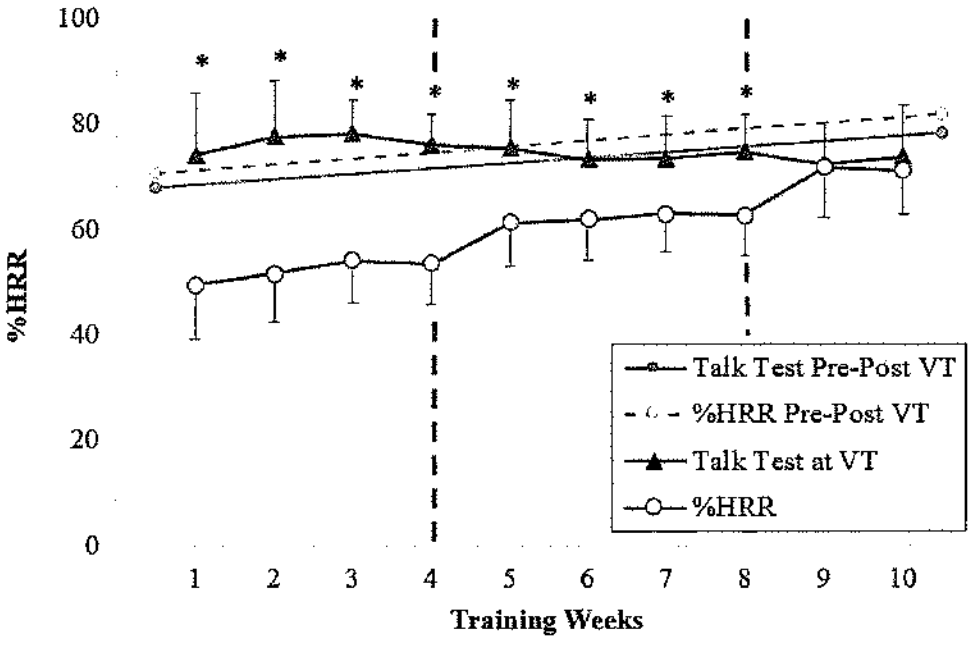

Figure 10. Comparison of training heart rates between the Talk Test at +/-, or EQ, and HRR group across weeks of training. Accepted ACSM range for %HRR are shaded.
*Significant difference between groups ($p<0.05$).

The week by week responses of PO in relation to pre and post incremental tests are presented in Figure 11. The PO values at the EQ, a surrogate of VT, within the TT group are significantly higher than those PO averages by week within the HRR group in weeks 1-5, and eight. Within week to week averages, both the TT group at VT and the HRR group train below values compared to the pre and posttests. Vertical dashed lines at week four and eight indicate a change in %HRR ranges the HRR group trained within.

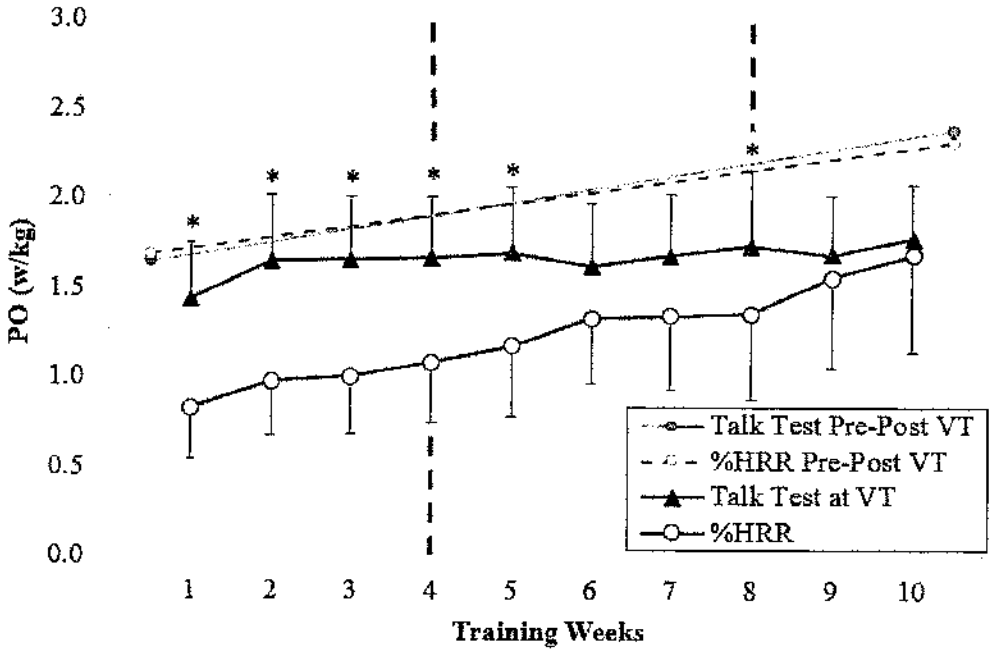

Figure 11. Comparison of PO values between the Talk Test at +/-, or EQ, and HRR group across weeks of training.
*Significant difference between groups ($p<0.05$).

Considering just the TT group, Figure 12 and Figure 13 illustrate the relationship between the average weekly TT scores at +/-, the surrogate of VT, compared to the average weekly TT training scores. Figure 12 demonstrates that generally, the %HRR of the TT group during training, trained just below the VT. The shaded window represents that regardless if at pre %HRR at VT, weekly %HRR average, average %HRR at VT, or post %HRR at VT, all averages remained within the ACSM guidelines. Likewise, Figure 13 illustrates pre and post PO in W per kilogram remain higher than averages during training. Similarly, the average TT training PO remains just under those PO values within the TT group at VT.

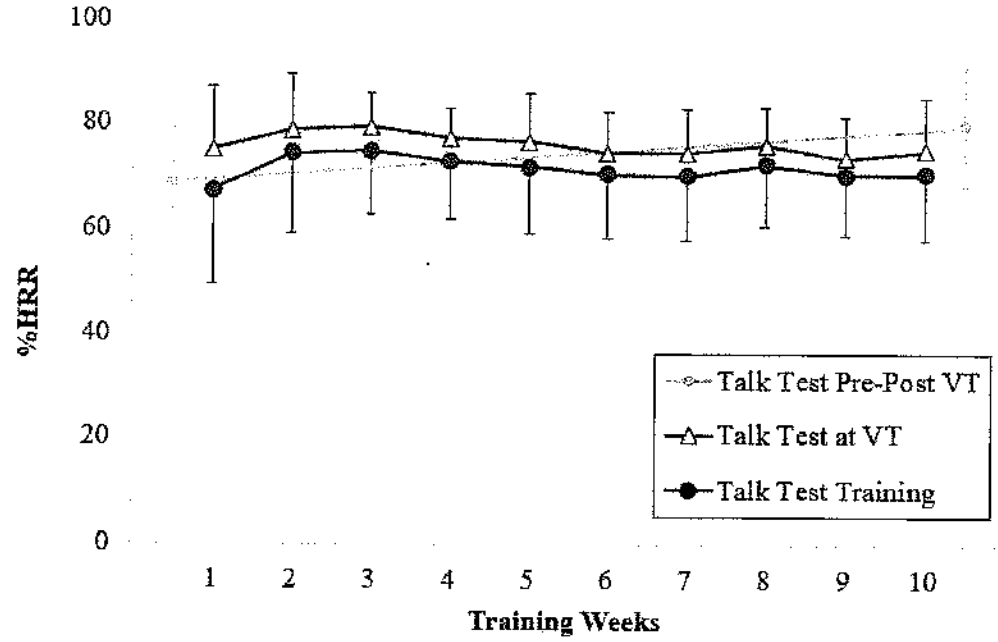

Figure 12. Comparison of heart rates between the Talk Test group during Training and the Talk Test group at +/-, or EQ, across weeks of training. Accepted ACSM range for %HRR are shaded.

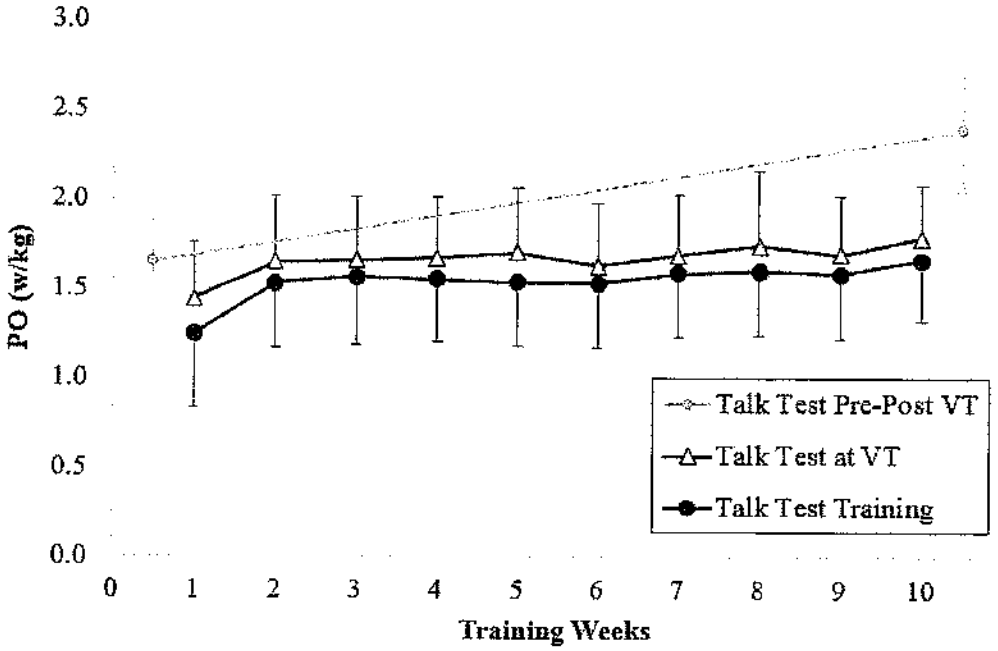

Figure 13. Comparison of PO between the Talk Test during Training and the Talk Test group at +/-, or EQ, across weeks of training.

DISCUSSION

The main finding of this study is both the TT and the %HRR training can be used to control training in healthy, sedentary individuals. The intensity of exercise under both control mechanisms fits within the window defined by professional society guidelines relative to %HRR, RPE and training just below the intensity at the VT.

Although the average intensity of both intensity control techniques was clearly within the window suggested by ACSM guidelines, approximately 25% and 14% of %HRR values were outside the target window in the HRR and TT groups, respectively. These values were considered based on individual data points that fell outside the nominal momentary target of 20% HRR window for the HRR group and the 40-90% HRR window for the TT group; both based on ACSM guidelines. The fluctuation at the momentary %HRR outside the nominal training window was slightly more frequent in the HRR group than in the TT group, potentially because the target intensity window was smaller in the HRR group. Training protocol was based on a change in PO for both the HRR and TT groups to meet criteria to control the average training intensity within desired parameters. Although it seems unlikely that training intensity could, in any practical situation, be controlled any more often than every five minutes, one could envision a scenario, partially with %HRR control, where the PO could be adjusted virtually instantaneously. Given the TT group is trained at an active control and that there are probably residual effects of talking while training, it seems unlikely that the TT could be measured more frequently than every five minutes.

The Rainbow Passage is a 101-word passage adopted from the speech pathology literature for an earlier study of the TT (Dehart-Beverley et al., 2000). Subsequently studies have also used the "Pledge of Allegiance", a shorter 31 work passage that is familiar, to most people within American culture. However, recent studies (Foss, M., Foster, C., Porcari, J. P., Mikat, R. P., Schmidt, K., 2015) have demonstrated that the error in estimating the intensity at the VT and RCT is smaller with longer speech production tools. Accordingly, this study used the Rainbow Passage and evidence within the training demonstrated that we were able to keep the intensity training just below VT.

The present results are similar to those of Woltmann et al. (2015) in that the TT was "clamped" between the LP and EQ stages (Figure 9). However, we used a longer speech passage (101 verse 31 words) and less frequently (five minutes verse two minutes) measured speech production score. Furthermore, the TT group averaged somewhere between 13.14 and 13.71 for weeks 2-10 and just shy of 13 in week one at an average of 12.61. This can be compared to the improved physical health found with perceptually regulated training around an RPE of 13 (Parfitt, Evans, & Easton, 2012). Nevertheless, the TT group scored NEG less than 8% of the time and the average training intensity remained just below the VT (Figure 9).

The overall impression from the study was that we were able to use both the %HRR and the TT methods to control training intensity within the windows recommended by ACSM guidelines (Pescatello, 2014). However, in this study we had the luxury of a preliminary maximal exercise test that allowed us to define %HRR. In the absence of a preliminary maximal test, controlling training using %HRR is impossible (Robergs & Landwehr, 2002). Accordingly, the much simpler TT method, which is

rather convenient and does not require a pre maximal exercise test, achieves the same training goal and is quite attractive.

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APPENDIX A

INFORMED CONSENT

UNIVERSITY of WISCONSIN
LA CROSSE

Prospective Research Participant:

You are invited to participate in our research study entitled *Training Effect on Talk Test vs Heart Rate Reserve* conducted by graduate students, Kate Falck, Sam Suckow, Jillian Turek, Anna Wargowsky, Dr. Carl Foster, Ph.D., and Dr. John Porcari, Ph.D. The main purpose of this study is to compare the training effect between using heart rate reserve and the talk test as exercise intensity measures. Participation in this study may benefit you, along with the general population, by gaining knowledge of how individuals respond to difference exercise training intensity measures. Direct benefits you *will* experience include increasing your physical fitness and living a healthier lifestyle.

If you decide to participate in the study, you will be asked to fill out a Physical Activity Readiness Questionnaire (PAR-Q) and sign an informed consent. If no exclusion criteria exists, you will complete a pre-maximal exercise test in order to evaluate fitness level. You will be required to wear a scuba type breathing valve and a chest strap to measure heart rate during the exercise test. After completion of the pre-maximal exercise test, you will be randomly divided into one of the 2 training groups for 10.5 weeks (3 times weekly for 40 minutes per session). Following the 10.5 week training portion, you will complete a post-maximal exercise test. During both pre and post testing along with training sessions, you will be asked to complete several questionnaires about the perceived exertion and the enjoyability aspect of the session. The enjoyability questions will be asked twice a week before, during, and after the training session to gauge how the enjoyability may change over time.

Participation is completely voluntary. By returning your completed PAR-Q and informed consent, you are giving your consent to participate in this study. All data will be coded to maintain confidentiality; thus, no data will be personally identified with you. Your name will not appear in any presentation or publication coming from this research. If you agree to participate, you may choose not to answer any given questions, and you may withdraw your consent and discontinue your participation at any time. There are no known risks beyond the inconvenience of time and mild discomfort in wearing the breathing mask or heart rate monitor. Additional symptoms you may experience during the exercise tests and training sessions include perspiration, be out of breath, and leg fatigue. You will be under supervisor at all times, and the primary investigators are all certified in CPR/First Aid and Advanced Cardiac Life Support, and the test will be terminated if complications should arise.

If at any time you have questions about this study, you may contact, Kate Falck, Sam Suckow, Jillian Turek, or Anna Wargowsky via email: **cepresearch16@gmail.com** or their advisors, Dr. Carl Foster (608-785-8687) or Dr. John Porcari (608-785-). Questions regarding the protection of human subjects may be addressed to the UW-La Crosse Institutional Review Board of the Protection of Human Subjects (608-785-8124 or irb@uwlax.edu).
Thank you for your consideration in participating in this study!

UNIVERSITY of WISCONSIN
LA CROSSE

Informed Consent Form

Title of Investigation: *Training Effect on Talk Test vs Heart Rate Reserve*

Names of Principal Investigators: Kate Falck, Sam Suckow, Jillian Turek, or Anna Wargowsky

This document is to certify that I, _____, hereby freely agree to participate as a subject in a research study as an authorized part of the educational and research program of the University of Wisconsin-La Crosse under the supervision of Dr. Carl Foster, Ph.D and Dr. John Porcari, Ph.D.

- The research project has been fully explained to me by Kate Falck, Sam Suckow, Jillian Turek, or Anna Wargowsky, and I understand this explanation, including what I will be asked to do. A copy of the procedures of this investigation and a description of any risks, discomforts and benefits associated with my participation has been provided and discussed in detail with me.

- I have been given an opportunity to ask questions, and all such questions and inquiries have been answered to my satisfaction as well as I am free to decline to answer any specific items or questions in interviews or questionnaires.

- I understand that, in the event of physical injury resulting from this investigation, neither financial compensation nor free medical treatment is provided for such physical injury.

- I certify that to the best of my knowledge, I have no physical or mental illness or weakness that would increase the risk during participation in this investigation.

- I understand that participation in this research project is voluntary and not a requirement or a condition for being the recipient of benefits or services from the University of Wisconsin-La Crosse or any other organization sponsoring the research project.

- I understand that the approximate length of time required for participation in this research project is 22 hours.

- I understand that if I have any questions concerning the purposes or the procedures associated with this research project, I may call or write to the principal investigator(s) or to the Institutional Review Board for the Protection of Human Subjects.

- I understand that it will not be necessary to reveal my name in order to obtain additional information about this research project from the principal investigator(s).

_____ _____

Signature of Subject Date

_____ _____

Signature of Investigator Date

APPENDIX B

EXERCISE HISTORY QUESTIONNAIRE

UNIVERSITY of WISCONSIN
LA CROSSE

Exercise History Questionnaire

1. **Are you currently involved in regular endurance (cardiovascular) exercise? If so, how many minutes/days a week do you engage in this activity?**

   Yes ☐ **No** ☐ **If Yes, _____ Days/Week for _____Minutes/Session**

2. **Do you currently play a sport or other recreational activities (besides HPR 105 Lab)? If yes, what types of sports/physical activity?**

   Yes ☐ **No** ☐ **If Yes, explain** _____

3. **Does your job involve physical labor?**

   Yes ☐ **No** ☐

4. **In the past 6-8 weeks, explain what you have done for physical activity?**

_____

_____

_____

_____

_____

APPENDIX C

PHYSICAL ACTIVITY READINESS QUESTIONAIRE—PAR-Q & YOU

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 or GUARDIAN (for participants under the age of majority) _____ WITNESS _____

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.

APPENDIX D

RATING OF PERCEIVED EXERTION (6-20 SCALE)

Rating of Perceived Exertion (6-20 Scale)	
6	
7	Very, Very Light
8	
9	Very Light
10	
11	Fairly Light
12	
13	Somewhat Hard
14	
15	Hard
16	
17	Very Hard
18	
19	Very, Very Hard
20	

APPENDIX E

RATING OF PERCEIVED EXERTION (0-10 SCALE)

Rating of Perceived Exertion (0-10 Scale)	
0	Nothing At All
0.5	Very, Very Light
1	Very Light
2	Fairly Light
3	Moderate
4	Somewhat Hard
5	Hard
6	
7	Very Hard
8	
9	
10	Very, Very Hard

APPENDIX F

THE RAINBOW PASSAGE

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

APPENDIX G

REVIEW OF THE LITERATURE

REVIEW OF THE LITERATURE

Introduction

Unfortunately, on the perpetual rise, sedentary behavior and obesity have become a worldwide epidemic. With progressive health concerns about sedentary behavior, the American Heart Association (AHA) and the American College of Sports Medicine (ACSM) have recently revised physical activity (PA) recommendations in 2007 to compensate for the health deficit (Pescatello, Areana, Riebe, & Thompson, 2014 & American Heart Association, 2015). These recommendations, tailored for healthy adults age 18-65, recommend engaging in 20-60 minutes of moderate to vigorous aerobic activity at least 3-4 times per week or 150 minutes of moderate intensity PA per week. Including aerobic activity, muscular strength and endurance should be practiced twice per week to encourage metabolic health and cardiovascular fitness (Pescatello, 2014). These PA guidelines by the ACSM and AHA are encouraged and prescribed based on the FITT-VP principle. The FITT-VP principle stands for frequency (how often), intensity (how hard), time (how long), type (what kind), volume (how much), and progression (change of all factors over time) (Pescatello, 2014 & American Heart Association, 2015). Although there has been research supporting the FITT-VP principle in general for recommendations, intensity is hard to measure during exercise without using a clinical setting for expensive equipment and measures. Although all of these measures can indicate exercise capacity, they are not all fiscal, practical, or timely measures of exercise intensity.

Current gold standard measures of exercise are based on a maximal exercise test where maximal oxygen uptake (VO_2max), maximal heart rate (HRmax), heart rate reserve (HRR), ventilatory threshold (VT), metabolic equivalents (METs), and Rating of

Perceived Exertion (RPE) can be calculated. The current ACSM recommendations for intensity include 40%-60% HRR or VO_2max for moderate intensity exercise or 60%-90% HRR or VO_2max for vigorous intensity exercise (Pescatello, 2014). The HRR can be calculated by taking a HRmax, from a maximal exercise test, and subtracting resting heart rate (HRrest). Although these methods are preferred to determine exercise intensity, they are not always readily available for the general population.

Heart Rate

The widely known, easy method for estimating HRmax is the use of a formula, 220-age. Surprisingly, there is no history of publication on research regarding this equation. Robergs & Landwehr (2002) note that Sid Robinson may have shown a guestimate of this formula based on observation and a linear best fit line dating back to 1938. Although used in daily exercise prescription for intensity, this easy formula should not be used without support of an exercise test as it does not account for personal factors varying between each individual. Additional equations have been formulated to take into account factors of HRmax such as age, health, sex, and medications, but even those are often geared to a specific population. Yet the formula 220-age has been engrained in the public's vision as the measure of HRmax. Ultimately, HRmax does not take into account the older population who are physically fit and the young individuals who are not; over or underestimating HRmax, respectively. The only accurate way to determine HRmax is from the conduction of a maximal exercise test where VO2max can also be found.

Rating of Perceived Exertion

The need for a subjective form of intensity measurement is evident, and the RPE Scale (Borg, 1998) was developed. Given each individual had a different perspective,

Gunner Borg created the 6-20 RPE scale to measure ones' perception of functional exertion. As Roger Eston (2012) indicates in his research regarding RPE and sport, RPE is driven by psychological factors and situational factors. Psychological factors such as cognition, past experiences, and understanding of the function being performed play a part in RPE. Duration and progression of the task are situational factors of RPE. Environmental factors such as temperature (Crewe, Tucker, & Noakes, 2008), ambient partial pressure of oxygen (Johnson et al., 2009), and duration (Pires et al., 2011) also play a large role in changes of RPE. In comparison to HR, the 6-20 scale has been matched to approximately 60-200 beats per minute which complement each other, but should not stand alone in exercise prescription.

An important study to subjective measure using the RPE scale and a normal training response occurs when RPE is "clamped" at 13 (Parfitt, Evans, & Easton, 2012). Additional data suggests patients who self-select RPE would likely chose between rates of 10-14 which has a positive affective response (Ekkekakis, 2004). Parfitt et al. (2012) lands between these parameters by suggesting participants to exercise at an exertion of 13, somewhat hard, to reach improved fitness and cardiovascular health.

After first creating his 6-20 scale, Borg (1998) changed his view on of the original scale to a category-ratio scale 0-10 (CR10). Although the 6-20 scale is still widely used, the idea of changing to the CR10 was to enhance the association of verbal expressions with numbers. Another branch regarding RPE is a session RPE (sRPE) created by Foster et. al (2001) which is similar, but not identical to the CR10 scale. This scale was concluded to quantify an average RPE of a whole session using a wide variety of exercise means. Although the RPE scale has been the gold standard for subjective measure of

personal intensity, finding another alternative for intensity measure in activities of daily living is still being researched.

Ventilatory Threshold

Found using only a maximal exercise test, the VT is when ventilation surpasses the point of oxygen (O2) consumption and carbon dioxide (CO2) expiration. Ventilatory threshold is used to define aerobic fitness, anaerobic threshold, and in recent research is bridging measures such as HR and RPE training to common HR and RPE measures found with Talk Test (TT) training. Given that ventilatory carbon dioxide (VCO2) is greater than ventilatory oxygen (VO2), blood lactate and acidosis build up in the body causing fatigue. Since VO2max tests show a linear regression initially, the immediate non-linear point or change in the graph would indicate VT has been reached (Beaver, Wasserman, & Whipp, 1986). Since the production of speech requires a suppression of breathing frequency, an increase in ventilation at the VT makes speech less comfortable.

Talk Test

Given gold standard objective measures and subjective RPE scales have been used as intensity measures, an even more practical alternative, the TT, has been created to reach out to the general population. It is known that in order to create sound, air needs to be expelled from the lungs to initiate vocal cord activity. Bridging forms of exercise while conversing, the TT can create a hypoxic environment in the lungs with more expiration than inspiration during too high of exercise intensities (Doust & Patrick, 1981). Dating back to 1939, Professor Grayson initiated the concept of the TT by encouraging his British mountaineers to "climb no faster than you can talk". Publishing some of the earliest research regarding the TT was Goode, Mertens, Shaiman, & Mertens

(1998) indicating that exercising at a level where subjects could "hear their breathing" was at or near the VT. Since then, the TT has progressed to the increased ventilation with speech production to guide exercise intensity and exercise testing (Doust & Patrick, 1981; Meyer, Samek, Pinchas, Baier, Betz, & Roskamm, 1995).

The validity of the TT has been demonstrated in a wide variety of populations as a form of an exercise intensity marker. The TT stages can be categorized as the Last Positive (LP or +), the Equivocal (EQ or +/-) stage, or the first Negative (NEG or -) stage. The LP indicates the subject could speak very comfortably during exercise training sessions. The EQ stage specifies the subject can speak during exercise, but not as comfortably as the LP stage. Finally, the NEG stages indicates that speech production cannot be formed during exercise and it would be very hard for the subject to complete even a few words at a time (Woltmann et al., 2015). Woltmann et al. (2015) explored the physiological impact of "clamping" or adjusting the TT at certain intensity levels such as Positive (POS), EQ, and NEG and found TT is an effective, isolated tool for prescribing exercise for sedentary adults to improve cardiovascular fitness below VT, or ineffective above. In support of this, Foster et al. (2009) and Jeans, Foster, Porcari, Gibson, & Doberstein (2011) included that incremental steady state training intervals can be used by choosing the stage before the LP (LP-1) for sedentary individuals, simply choosing the LP for active subjects, or following Lyon et al. (2014) using LP-1 or an LP-2 for patients with cardiovascular disease.

Extensive research has shown the validity and reproducibility of the TT as a simple, subjective measurement for prescribing exercise intensity just below the VT. Clinical patients with cardiovascular disease (Engen, Foster, Porcari, & Eber Lee, 2015;

Doro, Foster, Porcari, & Eber Lee, 2015), patients with myocardial revascularization (Zanettini et al., 2013), sedentary individuals, and the highly trained athletes and cyclists (Recalde et al. 2002; Rodriquiz-Marroyo, Villa, Garcia-Lopez, & Foster, 2013) have all shown strong evidence that the TT results in positive training for intensity. Shown in cardiac patients, Brawner et al. (2006) found the TT stimulated HR and RPE measures that agreed, within range, with exercise recommendations for this population at the time of the study; likewise, this HR achieved correlated with VT. Furthermore, sedentary individuals were found to have the most response to HR and RPE measures at the LP-1 where speech was ranked almost directly between "comfortable speech" and "slightly uncomfortable speech" (Foster, 2009). In higher trained athletes, safety within exercise training programs while training near or at the VT can occur since surpassing the VT would result in increased ventilatory frequency and therefore, inconsistent speech patterns (Dehart-Beverley et al., 2000).

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