Relationship Between the Talk Test and Ventilatory Thresholds in Well-Trained Cyclists

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Abstract

Rodríguez-Marroyo, JA, Villa, JG, García-López, J, and Foster, C. Relationship between the Talk Test and ventilatory thresholds in well-trained cyclists. *J Strength Cond Res* 27(7): 1942–1949, 2013—The aim of this study was to extend the range of populations where the Talk Test (TT) might be used as a marker of physiologic thresholds. Eighteen highly trained cyclists underwent 2 incremental tests. One test included measurement of respiratory gas exchange to determine the ventilatory (VT) and respiratory compensation thresholds (RCTs). On a separate day, a TT was performed using the same exercise protocol. During TT, subjects read a standard paragraph at the end of each stage. The first stage at which the cyclists could not talk comfortably and could definitely not talk were referred to as the equivocal (EQ) and the negative stages (NEG), respectively. There were no significant differences in workload, heart rate, lactate, and rating of perceived exertion between VT (3.7 $\pm$ 0.4 $W \cdot kg^{-1}$, 150 $\pm$ 10 $b \cdot min^{-1}$, 1.6 $\pm$ 0.3 $mm \cdot L^{-1}$, and 4.1 $\pm$ 1.4, respectively) vs. EQ (3.6 $\pm$ 0.4 $W \cdot kg^{-1}$, 148 $\pm$ 12 $b \cdot min^{-1}$, 1.3 $\pm$ 0.5 $mm \cdot L^{-1}$, and 3.8 $\pm$ 1.2, respectively) and RCT (5.3 $\pm$ 0.4 $W \cdot kg^{-1}$, 177 $\pm$ 7 $b \cdot min^{-1}$, 4.0 $\pm$ 0.9 $mm \cdot L^{-1}$, and 7.2 $\pm$ 1.0, respectively) vs. NEG (5.3 $\pm$ 0.5 $W \cdot kg^{-1}$, 176 $\pm$ 10 $b \cdot min^{-1}$, 4.2 $\pm$ 1.3 $mm \cdot L^{-1}$, and 6.8 $\pm$ 1.5, respectively). We found significant relationships ($p < 0.01$) between VT and EQ and RCT and NEG for workload ($r = 0.86$ and 0.94, respectively), heart rate ($r = 0.79$ and 0.92, respectively), and rating of perceived exertion ($r = 0.79$ and 0.88, respectively). In conclusion, the present study showed that the EQ and NEG stages of TT can be used as a simple and practical surrogate of the VT and RCT in highly trained cyclists.

Key Words performance, exercise testing, cycling, training intensity

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Introduction

The assessment of physiologic thresholds is an important tool for defining endurance capacity (8), especially among subjects of homogenous performance level (25). It has been shown that the exercise intensity at physiologic thresholds is more sensitive to changes in aerobic fitness than $\dot{V}O_2max$ (24). Furthermore, physiologic thresholds have been shown to be well related to endurance performance in sports such as athletics and cycling (1,28). From a practical point of view, data obtained at physiologic thresholds can be used to prescribe training intensities (5,15,28). Different investigators have proposed that training prescription is better defined by exercise intensity relative to physiologic thresholds than those relative to maximal values (e.g., $\%\dot{V}O_2max$ or %HRmax) (21,34,35). Usually, it has been established 3 intensity zones using the reference heart rate (HR) corresponding to physiologic thresholds: below the ventilatory or lactate threshold, between the ventilatory and respiratory compensation thresholds (RCTs), and above the RCT or the intensity associated with a blood lactate concentration of approximately 4 $mmol \cdot L^{-1}$ (12,23,33,35).

Physiologic thresholds can be measured using a variety of techniques. Principally, blood lactate concentration and ventilatory variables have been used for threshold determination (5,8,12,23–26,28,33). These methods require the use of sophisticated equipment (e.g., respiratory gas or blood lactate analyzers) and must be administered by qualified personnel. This limits access to these tests, often only to professional or elite athletes, which can limit the endurance performance assessment and the training intensity prescription of many athletes.

Several studies have validated the use of simpler methods to examine physiologic thresholds (7,10,26,38). Among these simpler methods is the Talk Test (TT) (9,13,14,19,30–32,37). The TT derives from the advice given by Professor Grayson, in 1939, to British mountaineers to "climb no faster than you can speak" and to the "breath check test" devised in Canada (16). The TT is usually performed as an incremental test where the subjects' ability to speak comfortably is

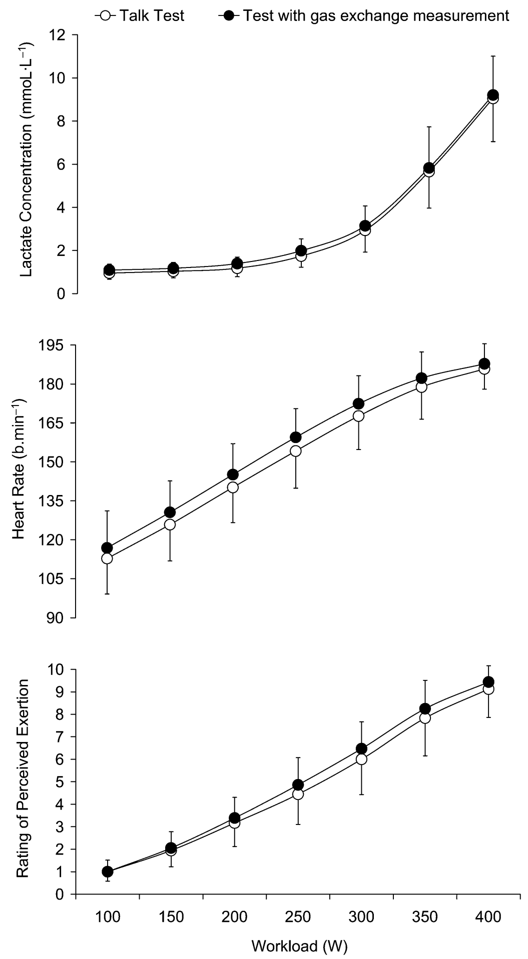

Figure 1. Comparative responses of lactate concentration, heart rate, and RPE during TT and the exercise test with gas exchange measurement ($n = 18$). Values are mean ± *SD*. RPE = rating of perceived exertion; TT = Talk Test.

evaluated. It has been shown that TT is a surrogate of the ventilatory or lactate thresholds in a variety of populations, including trained nonathletes (9,13,30,31), recreational level athletes (19,32), and patients with chronic disease (37). However, no study has analyzed if the TT outcomes can be used to estimate the ventilatory (VT) and RCTs in trained or highly trained athletes. Therefore, the aim of this study was to extend the range of populations where TT might be used as a marker of physiologic thresholds. We hypothesized that the use of TT would be a valid alternative method of estimating the VT and RCT in highly trained subjects.

Methods

Experimental Approach to the Problem

To test that TT can be used to estimate the VT and RCT, we used a randomized counterbalanced design, where 18 well-trained cyclists performed 2 different incremental tests at the beginning of their competitive season (February). One of them included measurement of respiratory gas exchange to determine the VT and RCT according to the criteria of Davis (8). The other exercise test involved performing TT during an identical exercise protocol without use of the respiratory apparatus. During this test, the subjects read a standard paragraph at the end of each exercise stage and reported their ability to talk comfortably. The first stage at which the subjects cannot unequivocally talk comfortably or definitely cannot talk comfortably was compared with the VT and RCT analyzed during the test with gas exchange measurement, respectively (9,13,30,32,37). Both tests were separated by 7 days and performed at the same time of the day (between 10:00–13:00 hours) and under similar environmental conditions (20–25° C, 50–55% relative humidity).

Subjects

The subjects were 18 elite road cyclists (mean ± *SD*: age, 20 ± 2 years; height, 174.6 ± 6.2 cm; body mass, 62.3 ± 5.0 kg; and sum of 6 skinfolds, 38.7 ± 10.0 mm) belonging to an amateur team (under 23 years of age category of the International Cycling Union). The subjects had a competition experience of 7 ± 3 years and cycled between 20,000 and 25,000 km per season, in training and competition. The subjects were familiar with the exercise testing protocol as all had previously performed exercise tests in our laboratory. During the study, subjects slept (8–9 hours) and lived at 400–600 m altitude and trained 2–4 hours per day. The training and nutritional conditions under which the cyclists performed

Table 1. Maximal values (mean ± *SD*) measured during the exercise test with GXT and TT.*

	GXT	TT
$\dot{V}O_2$ (ml·kg^{-1}·min^{-1})	73.8 ± 2.8	
Workload (W)	406.3 ± 30.6	401.5 ± 35.4
Workload (W·kg^{-1})	6.5 ± 0.5	6.5 ± 0.6
Heart rate (b·min^{-1})	192 ± 7	191 ± 7
Lactate (mm·L^{-1})	10.4 ± 2.0	10.5 ± 1.6

*GXT = gas exchange measurement; TT = Talk Test.

Table 2. Values measured (mean ± *SD*) at VT, EQ, and LP.†

	VT	EQ	LP	η^2
$\dot{V}O_2$ (ml·kg^{-1}·min^{-1})	47.4 ± 4.5*	46.6 ± 4.5*	39.2 ± 4.1	0.72
$\dot{V}O_2$max (%)	64.3 ± 5.6*	63.2 ± 5.7*	53.1 ± 5.1	0.73
Workload (W)	227.8 ± 25.6*	222.2 ± 25.6*	172.2 ± 25.6	0.72
Workload (W·kg^{-1})	3.7 ± 0.4*	3.6 ± 0.4*	2.8 ± 0.4	0.73
Heart rate (b·min^{-1})	150 ± 10*	148 ± 12*	132 ± 12	0.71
Lactate (mm·L^{-1})	1.6 ± 0.3*	1.3 ± 0.5*	1.1 ± 0.3	0.41
RPE	4.1 ± 1.4*	3.8 ± 1.2*	2.3 ± 0.8	0.68

†VT = ventilatory threshold; EQ = first exercise stage at which the cyclists were not entirely certain about their ability to talk comfortably (equivocal stage); LP = last positive stage at which the cyclists were still unequivocally able to talk comfortably; η^2 = effect size in terms of partial eta squared; RPE = rating of perceived exertion.

*Significant difference with LP ($p < 0.001$).

all the tests were controlled. During the 48 hours before the testing sessions, the cyclists were instructed to avoid strenuous training sessions (i.e., 1–2 hours per day of easy bicycling) and to follow a carbohydrate-rich diet. No food intake was allowed during the 3 hours before testing. Written informed consent was obtained from all subjects, and the protocol was approved by the local ethics committee.

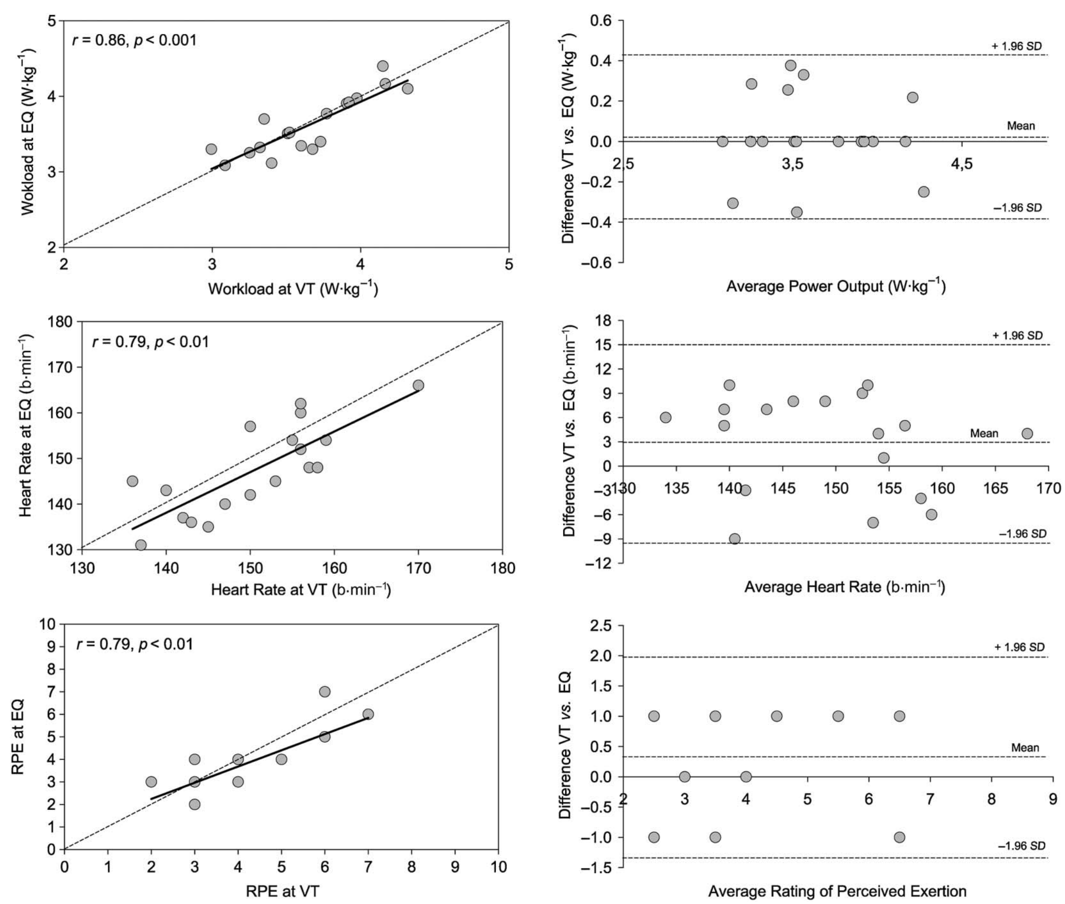

Figure 2. Agreement between workload, heart rate, and RPE at EQ and VT. Left graphs represent the relationship between variables. Right graphs represent the Bland-Altman plots with estimated bias and 95% limits of agreement. RPE = rating of perceived exertion; EQ = equivocal stage; VT = ventilatory threshold.

Table 3. Values measured (mean ± *SD*) at the RCT, NEG, and LEQ.†

	RCT	NEG	LEQ	η^2
$\dot{V}O_2$ (ml·kg^{-1}·min^{-1})	60.2 ± 4.5*	60.3 ± 4.8*	54.0 ± 5.2	0.72
$\dot{V}O_2$max (%)	81.6 ± 4.9*	81.6 ± 4.5*	73.1 ± 5.5	0.72
Workload (W)	327.8 ± 25.6*	330.6 ± 25.1*	280.6 ± 25.1	0.85
Workload (W·kg^{-1})	5.3 ± 0.4*	5.3 ± 0.5*	4.5 ± 0.4	0.85
Heart rate (b·min^{-1})	177 ± 7*	176 ± 10*	163 ± 11	0.72
Lactate (mm·L^{-1})	4.0 ± 0.9*	4.2 ± 1.3*	2.3 ± 0.7	0.68
RPE	7.2 ± 1.0*	6.8 ± 1.5*	5.2 ± 1.3	0.71

†RCT = respiratory compensation threshold; NEG = first stage at which the cyclists could not definitely talk comfortably (negative stage); LEQ = last exercise stage at which the cyclists were not entirely certain about their ability to talk comfortably (last equivocal stage); η^2, effect size in terms of partial eta squared; RPE = rating of perceived exertion.
*Significant difference with LEQ ($p < 0.001$).

Procedures

Exercise Tests With Gas Exchange Measurement. The test was performed on an electrically braked cycle ergometer (Lode Excalibur Sport; Lode Medical Technology, Groningen, the Netherlands) and was preceded by a 10-minute warm-up period at a workload of 100 W, with 5-minute recovery before beginning the incremental test. The initial workout was 75 W and was increased

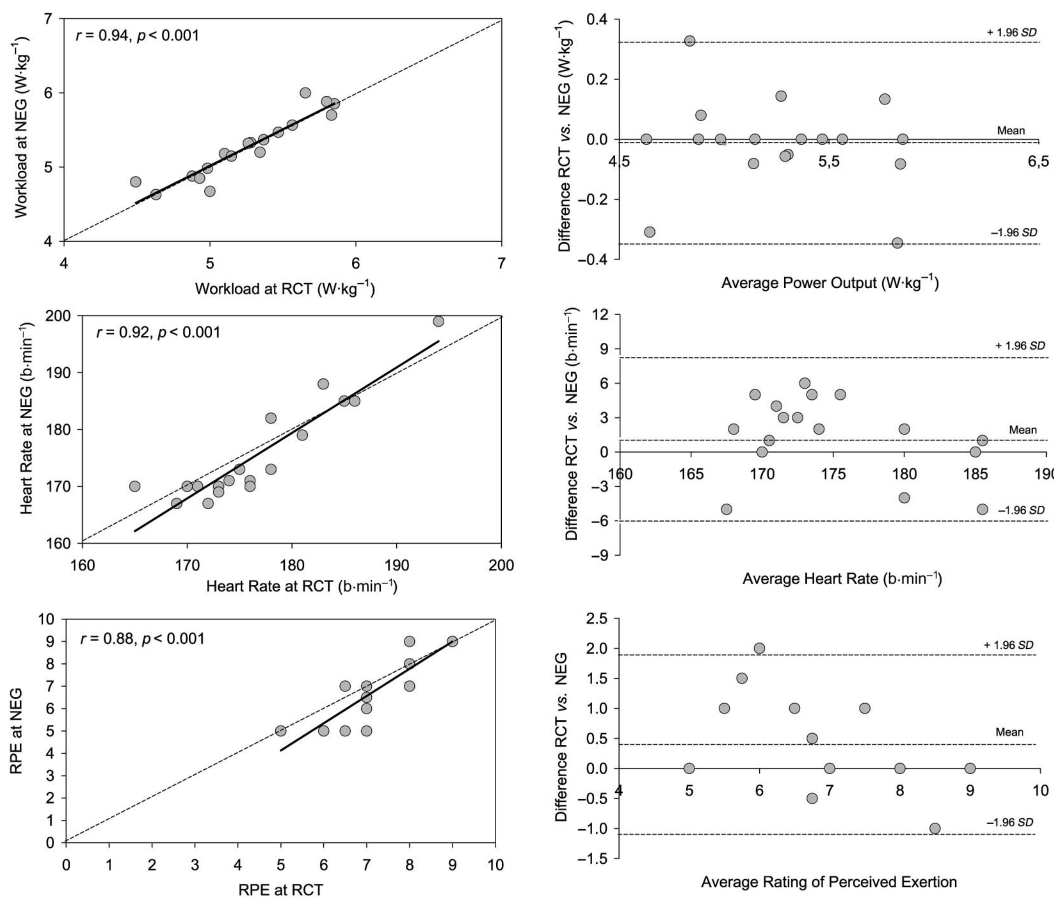

Figure 3. Agreement between workload, heart rate, and RPE at NEG and RCT. Left graphs represent the relationship between variables. Right graphs represent the Bland-Altman plots with estimated bias and 95% limits of agreement. RPE = rating of perceived exertion; NEG = negative stage; RCT = respiratory compensation threshold.

by 50 W every 2 minutes until volitional exhaustion. The maximal workload was determined as the highest workload cyclists could maintain for a complete stage plus the interpolated workload from incomplete stages (22).

The HR response was measured telemetrically every 5 second (Polar Vantage NV; Polar Electro Oy, Kempele, Finland), and respiratory gas exchange was continuously measured breath by breath (Medisoft Ergocard; Medisoft Group, Sorinnes, Belgium). The following gas exchange variables were measured: $\dot{V}O_2$, ventilation (VE), ventilatory equivalents for oxygen ($VE \cdot \dot{V}O_2^{-1}$) and carbon dioxide ($VE \cdot \dot{V}CO_2^{-1}$), and end-tidal partial pressure of oxygen ($PETO_2$) and carbon dioxide ($PETCO_2$). Data from the last 30 seconds of each exercise stage were considered representative measurements of each stage. Maximal $\dot{V}O_2$ and HR were recorded as the highest values obtained for the last 30-second period before exhaustion. The VT and RCT were identified separately by 3 researchers according to the criteria of Davis (8): increase in both $VE \cdot \dot{V}O_2^{-1}$ and $PETO_2$ with no concomitant increase in $VE \cdot \dot{V}CO_2^{-1}$ for VT, an increase in both $VE \cdot \dot{V}O_2^{-1}$ and $VE \cdot \dot{V}CO_2^{-1}$, and a decrease in $PETCO_2$ for RCT.

During the last 30 seconds of each exercise stage, the rating of perceived exertion (RPE) was recorded using the category ratio (0–10) RPE scale (4). The cyclists from this study had performed several incremental tests in our laboratory using the RPE scale and were familiar with the scale. Capillary blood samples were taken from a previously hyperemized earlobe to measure blood lactate concentration (Lactate Scout; Senslab, Leipzig, Germany).

Talk Test. The TT exercise protocol was identical to the exercise test with gas exchange measurement but without respiratory gas analysis. Instead, the cyclists recited aloud a standard paragraph (38 words) from a Spanish classic poem (*Son of the Pirate* by José de Espronceda) during the last 30 seconds of each exercise stage. The cyclists were familiar with this paragraph. Two weeks before the beginning of this study, a copy of the paragraph was sent to each subject. Moreover, a cue card was located in front of the cyclist to allow immediate reference to the text. Immediately, after reciting the paragraph, the cyclist was asked, "Can you talk comfortably?" Only 3 possible answers were recorded: "yes," which was referred to as "positive" result; "not sure," which was referred to as an "equivocal" result; and "no," which was referred to as a "negative" result. The last exercise stage at which the cyclists were still unequivocally able to talk comfortably was referred to as the last positive stage (LP). The first and last exercise stages at which the cyclists were not entirely certain about their ability to talk comfortably were referred to as the equivocal stage (EQ) and last equivocal stage (LEQ), respectively. Finally, the first stage at which the cyclist could definitely not talk comfortably was referred to as the negative stage (NEG). Starting from this stage, subjects did not continue to perform TT, although the protocol was continued to fatigue.

Parameters analyzed in TT were identical to those analyzed during the exercise test with gas exchange measurement. It was assumed that the respiratory and metabolic response during TT was the same as during the test with $\dot{V}O_2$ measurement (9,37). To eliminate the impact of cycling position (18) and pedaling cadence (2) during the tests, the cyclists used the same posture (i.e., upright sitting position) and maintained a pedaling cadence between 80 and 100 rpm. Likewise, seat and handlebar heights were kept constant for both tests.

Statistical Analyses

The results are expressed as mean ± *SD*. The Kolmogorov-Smirnov test was applied to ensure a Gaussian distribution of the results. An analysis of variance with repeated measures was used to compare the physiological variables recorded at the LP and EQ and LEQ and NEG of TT with those measured at the VT and RCT, respectively. When a significant *F* value was found, Bonferroni's test was applied to establish significant differences between means. The relationship between variables was determined by means of Pearson's correlation coefficient (r). The concordance between measures was assessed by calculating the intraclass correlation coefficient (ICC). Values of $p \leq 0.05$ were considered statistically significant. In addition, Bland-Altman method (3) for assessing agreement between VT vs. EQ and RCT vs. NEG was used. Partial eta squared (η^2) was calculated as an indicator of effect size. SPSS+ V.15.0 statistical software (SPSS, Inc., Chicago, IL, USA) was used.

Results

The lactate concentration, HR, and RPE analyzed throughout the test with gas exchange measurement and TT were not significantly different (Figure 1). There were no significant differences between the maximal values reached in both tests (Table 1). We found significant relationships and ICC between the maximal workload ($r = 0.95$, ICC = 0.97, $p < 0.001$) and maximal HR ($r = 0.81$, ICC = 0.89, $p < 0.001$).

When we compared the values measured at VT, EQ, and LP, no significant differences were found between VT and EQ. However, the values at LP were significantly less ($p < 0.001$, $\eta^2 \geq 0.41$) than those obtained at VT and EQ (Table 2). Significant relationships and ICC in workload ($r = 0.86$, ICC = 0.92, $p < 0.001$), HR ($r = 0.79$, ICC = 0.86, $p < 0.001$), and RPE ($r = 0.79$, ICC = 0.87, $p < 0.001$) between VT and EQ were found. The results of the Bland-Altman plots are shown in the Figure 2. This analysis demonstrated a good concordance between VT and EQ. The mean bias for HR and RPE was 3 ± 6 b·min^{-1} and 0.3 ± 0.8, respectively.

There were no significant differences between the physiological parameters at RCT and NEG. However, these parameters were significantly different ($p < 0.001$, $\eta^2 \geq 0.68$) than those at LEQ (Table 3). We found significant relationship ($p < 0.01$) between RCT and NEG for workload ($r = 0.94$), HR ($r = 0.92$), and RPE ($r = 0.88$). In addition, high measurement reliability was obtained. We found ICC of 0.97

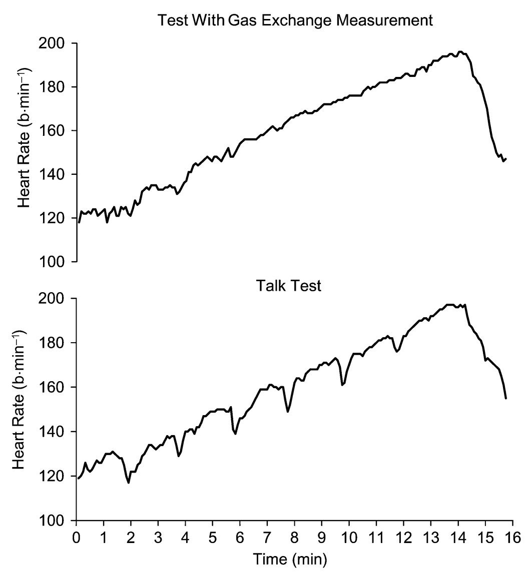

Figure 4. Individual example of heart rate pattern recorded during TT and the exercise test with gas exchange measurement. TT = Talk Test.

($p < 0.001$), 0.94 ($p < 0.001$), and 0.89 ($p < 0.001$) for workload, HR, and RPE, respectively. The Bland-Altman plots revealed good agreement between the variables measured at RCT and NEG (Figure 3). The mean bias ± 95% confidence interval of the between-method differences was found to be lower for RCT vs. NEG than VT vs. EQ.

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 work with other populations (9,13,30,32,37). These studies have shown that, in recreational level athletes (32), well-trained nonathletes (9,13,30), or patients with chronic disease (37), there is a good correspondence between VT and EQ. When speaking first became difficult, exercise intensity was equivalent to VT (80–85% HRmax or 75–80% $\dot{V}O_2$max) (9,30,32,37). However, when speech was not unequivocally comfortable, exercise intensity was above VT (9,30,32,37). Our results also support data reported previously by Recalde et al. (32) that NEG is a surrogate of RCT.

Our results disagree with the recent findings of Quinn and Coons (31). These authors found that the values analyzed at the VT were lower than those in TT but were associated with those obtained at the lactate threshold (31). These authors used the same protocol to perform TT and the lactate threshold test (3-minute stages). However, they performed a ramp test (1-minute stages) for analyzing the VT. It has been shown that VT is affected by the exercise protocol (20,36). However, in the current research and previous studies (9,30,32,37), the protocols used during TT and the exercise test with gas exchange measurement were similar, which facilitated the comparison of the variables (Figure 1). We used steps of 2 minutes, which could have affected the identification of VT and RCT. However, in all cyclists, the ventilatory thresholds were identified. By contrast, the performance of shorter stages (i.e., 1 minute) may have affected the ability of subjects to talk comfortably (9,13). Therefore, all studies from our laboratory have used stages of 2 minutes (9,13,14,19,30,37) or 3 minutes (32).

It would be reasonable to expect that the different respiratory pattern used during speech production in TT could systematically affect the overall response to the exercise bout. However, HR, RPE, and lactate concentration observed throughout the TT and exercise test with gas exchange measurement were similar (Figure 1). These results agree with those shown previously by Dehart-Beverley et al. (9). Meckel et al. (27) indicated that HR is not affected by speech production during submaximal exercise. It has been shown that there is a longer expiration time at both rest (6) and exercise (27) during speech, which requires a reduction in spontaneous breathing frequency. This fact decreased ventilation (11,27), which was associated with a decrease of $\dot{V}O_2$ and an elevation of lactate concentration (27). In the present study, ventilation was not measured during TT, to avoid the respiratory apparatus influencing the ability of the subjects to speak. However, we believe that the protocol used in this study did not seriously affect the ventilatory pattern because the subjects only spoke at the end of each stage, a paragraph of 38 words, which requires about 10–15 seconds of speaking. Moreover, the power output vs. lactate relationship observed was similar in TT and the gas exchange measurement test. By contrast, in the studies referenced above, subjects spoke continuously during the test.

Although there were no differences in HR through the different stages between the 2 tests (Figure 1), HR in TT was a little bit lower during speech during lower intensity exercise. During harder exercise, it tended to be similar (e.g., when subjects were not able to speak [bias of 3 and 1 $b \cdot min^{-1}$ in VT and RCT, respectively]). It has been demonstrated in both humans and animals that there is an interval fluctuation of cardiac cycle synchronous with the respiratory cycle (e.g., respiratory sinus arrhythmia). This is potentially attributable to modulation of premotor cardioinhibitory parasympathetic neuronal activity, which causes an increase and decrease in HR concurrent with inspiration and expiration, respectively (17,29). We speculate that this mechanism may influence the TT HR response. In some of the cyclists, we observed a decrease in HR at the end of TT stages (Figure 4). Future studies should systematically analyze this issue.

In summary, the results of the present study suggest the applicability of TT in highly trained cyclists, which extends the use of this technique to a broader population. These results support our hypothesis that EQ and NEG can be used as simple and practical surrogates of VT and RCT, respectively. Accordingly, it seems reasonable to suggest that TT may be a valid method of exercise prescription in highly trained subjects.

Practical Applications

Exercise testing is an important step in the training planning process. Physiological testing can help coaches to prescribe training intensity and assess the response to training programs. It is common in endurance sports to use gas analysis and lactate measurements to identify the ventilatory and lactate thresholds as markers of training zones. However, the requirement for sophisticated equipment and qualified personnel to perform these tests limits access to them, often limited to professional or elite cyclists. Data from this study have shown that TT is a simple, practical, noninvasive, and inexpensive tool to estimate the VT and RCT in competitive cyclists. This can be a useful tool for the coaches and cyclists who may not have access to laboratory testing. The use of TT not only can allow assessment of subelite cyclists but also can allow repeated assessment throughout the season because of its low cost. This can help coaches to monitor the training progress and the effectiveness of training programs.

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