CAN THE TALK TEST BE USED TO PREDICT TRAINING INDUCED CHANGES IN VENTILATORY THRESHOLD?

Kristen M. Deal[1,2], Carl Foster[1], Salvador Jaime[1], Richard P. Mikat[1], Kim Radtke[1], and John P. Porcari[1]

[1]University of Wisconsin – La Crosse, La Crosse, WI
[2]University of Wisconsin – Milwaukee, Milwaukee, WI

Original scientific article
DOI: 10.26582/k.52.2.1

Abstract:

This study was designed to assess the ability of the Talk Test (TT) to track training-related changes in ventilatory threshold (VT). Thirteen recreational athletes (20.5±1.91 years, males=7) completed two incremental exercise tests (one with respiratory gas exchange and one with the TT) before and after six weeks of self-directed increases in training load. The TT was used to predict VT by assessing the ability to speak comfortably after three-minute exercise stages, based on speech comfort while reciting a 100-word passage. Training load was documented from exercise logs based on session rating of perceived exertion (sRPE) and training duration. Repeated measures ANOVA, with the Tukey's *post-hoc* analysis, was used to detect differences between the changes in power output (PO) at the equivocal stage (EQ) of the Talk Test and VT measured by gas exchange ($p<.05$). Significant mean differences were found between pre- vs. post-training PO and measured VT (116±32.4 vs. 134±32.4 Watts) ($p<.05$) but not at the EQ stage of the TT (125±40.8 vs. 135±29.8 Watts). The increase in PO at VT (+15.5%) was significantly underestimated by the change in PO at the EQ stage of the TT (+8.0%). The correlation between changes in PO at VT and PO at the EQ stage of the TT was $r=0.66$, $p<.01$. However, about 50% of participants did not change their PO at the EQ stage of the TT, so the individual correspondence between TT and measured VT was only moderately strong.

Key words: *aerobic capacity, equivocal stage, exercise prescription*

Introduction

The prescription of exercise is intended to assist in improving health and physical performance. Current recommendations for training intensity prescription (ACSM, 2017) are based on percentages of maximum heart rate reserve (%HRR) or of maximal oxygen uptake (%VO_2max), which require maximal effort exercise testing. Alternative methods for obtaining maximum HR, such as age dependent formulas (either 220 – age or 210 – 0.7*age), give acceptable population estimates of maximum HR, but are marginally accurate on an individual basis (Marx, et al., 2018). Even when a measured maximal HR is available, Katch, Weltman, Sady, and Freedson (1978) noted that the %HRR training method may not stress different individuals to the same degree in relation to energy metabolism. Similarly, Scharhag-Rosenberger, Meyer, Gäßler, Faude, and Kinderman (2010) found that exercising at a standard %VO_2max led to non-homogeneous metabolic strain even in individuals with comparable exercise capacity. More recent guidelines for populations ranging from cardiac patients to athletes have suggested that training should be organized with reference to the lactate or ventilatory threshold (VT), with the majority of training occurring at an intensity just below the VT (Mezzani, et al., 2012; Seiler, 2010). However, direct identification of the VT is technically challenging outside the setting of research laboratories.

Based on observations from the late 1930s of the correspondence between speech comfort and the sustainability of exercise, Goode and associates (Goode, R. Mertens, Shaiman, & J. Mertens, 1998; Goode, 2008) found that simply asking an individual if they could "hear their breathing" while they were exercising resulted in HR responses that were within conventional guidelines for prescribing exercise intensity. This formed the background for the Talk Test (TT), which has since been of interest relative to exercise prescription (Foster, et al., 2018). The TT is a simple technique, requiring an individual to determine if they can "talk comfortably" in response to a standard speech provoking stimulus. Responding "yes," represents a "positive" (POS) stage, with the intensity usually below the PO at the VT (Foster, et al., 2018). When the exerciser is not sure whether he/she can speak comfortably, the stage is called the "equivocal" (EQ) stage, typically occurring at an intensity that approximates the VT (Foster, et al., 2018; Rodriguez-Marroyo, Villa, Garcia-Lopez, & Foster, 2013; Woltmann, et al., 2015). The "negative" (NEG) stage of the TT begins when the exerciser cannot speak comfortably, and typically occurs at an intensity that approximates the PO at the respiratory compensation threshold (RCT) (Foster, et al., 2018; Rodriguez-Marroyo, et al., 2013; Woltmann, et al., 2015). The simplicity of the TT has inspired considerable research to determine its validity (Foster, et al., 2018) and reliability (Ballweg, et al., 2013) for prescribing exercise intensity. Research has shown that the TT is a useful surrogate for both the VT and RCT not only in healthy individuals, but also in cardiac patients and athletes (Brawner, et al., 2006; Foster, et al., 2008, 2009; Gron Nielsen, et al., 2014; Rodriquez-Marroyo, et al., 2013; Voelker, et al., 2002, Zanettini, et al., 2013).

Because of its simplicity, the TT has been evaluated relative to its ability to track intervention related changes in exercise capacity. Foster et al. (2008) examined the effect of a 6-week training program on VT in previously sedentary individuals in relation to the TT for tracking changes in VT using the EQ stage of the TT. They found that VT increased in parallel with the TT following training and further demonstrated that the EQ stage of the TT and the VT decreased in parallel following blood donation (e.g. reduction of hemoglobin mass). Since Foster et al. (2008), there have not been studies assessing the relationship of the TT and VO_2 relative to changes in VT in responses to changes in training status. Accordingly, the purpose of this study was to observe whether a change in VT can be tracked using the TT. We hypothesized that an improvement in VT PO after a period of training would also be observed in the TT with an improvement in the EQ stage of the TT PO.

Methods

Participants

The participants were healthy, well-trained, recreational athletes. All completed the Physical Activity Readiness Questionnaire (2017 PARQ+) to identify contraindications to exercise and provided written informed consent. The university human participants committee approved the protocol. The design was a longitudinal observational study without a control group, evaluating power output at the EQ TT and measured VT in response to spontaneous changes in training load. Descriptive characteristics of the participants are presented in Table 1. Participants were not included in the study if they had a musculoskeletal injury within the last six months, cardiac or pulmonary contraindications to exercise, and/or were pregnant. Out of 14 original volunteers, thirteen completed the study.

Table 1. Descriptive characteristics (M+SD) of participants

	Male (n=7)	Female (n=6)
Age (years)	21.7±1.89	19.6±0.98
Body weight (kg)	9.0±20.76	75.6±25.10
Body height (m)	1.8+0.06	1.7+0.12

Protocol

Prior to the first laboratory test, the participants recorded their training for two weeks to obtain an estimate of their baseline training load. Data recorded included time and intensity of exercise using the Borg CR-10 scale (Borg, 1998). The training load was calculated using the session RPE (sRPE) method (Foster, et al., 1995, 2001). After two weeks of baseline exercise logging, participants performed two maximum exercise tests. The tests were completed on separate days, at least 48 hours apart, on an electronically braked cycle ergometer (ExcaliburLode, Groningen, The Netherlands). The sequence of testing was randomly selected to either be a TT or with measurement of respiratory gas exchange (AEI Technologies MOXIS Modular VO_2 System, Pittsburg, Pennsylvania, USA). Two tests were completed during week one and two identical tests were completed during week six of training, separated by at least 12 hours from the last training session. Calibration was performed with standard reference gases and a three-Liter syringe. Heart rate was recorded using radio telemetry (Polar Vantage XL, Kempele, Finland). Each test began with a three-minute warm up at 25 Watts, at a cadence of 80-100rpm. The test continued with three-minute stages increasing by 25 Watts per stage until a cadence of 80-100rpm could not be continued, despite strong verbal encouragement. During the last 15 seconds of each stage, HR and rating of perceived exertion (RPE) using the Borg CR-10 (Borg, 1998) scale were recorded. During the last 45 seconds of each TT stage, participants recited a standard 101-word paragraph "the Rainbow Passage." Participants were then asked if they "were able to speak comfortably". They responded with "yes" if they could speak comfortably (POS stage), "yes, but" if it was beginning to feel difficult to speak (EQ stage), or "no" if they could no longer speak comfortably (NEG stage) (Goode, 2008). Peak PO was recorded from the Excalibur Lode cycle ergometer during the last 15 seconds of each stage. Following the completion of the test, PO for the EQ stage of the TT was determined by the first "yes, but" statement from the participant. The v-slope method was used to calculated VT time (Foster & Cotter, 2005). The time was then used to determine PO during VT.

After baseline tests were completed, participants continued to record their training for the next six weeks using the sRPE method (Foster, et al., 1995, 2001). Between the pairs of tests, the participants were asked to increase their training load (time, frequency, and intensity), but the specifics of the increase in training were self-directed. Training load was calculated as time*sRPE measured in arbitrary units (AU). About 70% of all training was completed by cycling, the remaining by running. Since we did not have a hypothesis about the quantitative relationship between changes in training load and changes in VT or performance, we felt that the best test of the ability of the TT to track changes in VT was to allow the participants to self-select the load of training, just as they would when preparing for a competition. Therefore, exercise was self-directed so as to not test a specific training regimen, but solely to test the ability of the TT to track changes in aerobic capacity. Physical activity was recorded daily, approximately 30 minutes following every exercise training, and records were obtained from participants twice a week via email or text message. Following the 6-week increase in the training load, the participants repeated the two tests.

Statistical analysis

Data are presented as mean±SD. Statistical analyses were made using SPSS statistics version 25. Data were analyzed using ANOVA with repeated measures to evaluate the hypothesis that changes in power output at the EQ stage of the TT would parallel changes in power output at VT. Tukey's *post-hoc* analysis was used to detect longitudinal differences when justified by the ANOVA results. The level of significance was set at $p<.05$. Additional analyses were made using linear regression to evaluate whether group responses were representative of individual responses.

Results

There was a significant increase in weekly training load from pre to post (715.3±607.74 AU to 1155.2±784.33 AU) ($p<.01$) (Figure 1). However, as the magnitude of change in training load was self-selected, there was a considerable variation in the magnitude of training load increase amongst the participants. Two participants increased their training load from pre to post more than the others due to being comparatively sedentary at the start of the study.

Variables assessed between pre- and post-testing are represented in Table 2 and Figures 2-4. There was no significant difference from pre to post for VO_2 max (L/min) ($p=.362$), VO_2 max (ml/kg/min) ($p=.322$), or TT EQ (Watts) ($p=.096$). However, there was a significant increase from pre to post in peak power output (PPO) (Watts) ($p=.032$), and PO at VT ($p=.008$). Although PO at EQ tended to increase (+8%), the magnitude of increase was not significant ($p=.096$). The magnitude of increase in PO at VT (+15.5%) was significantly greater than the change in PO at the EQ stage of the TT. The pattern of changes in PO at VT and EQ TT were similar but were characterized by failures to increase in about half the participants for PO at the EQ stage of the TT (Figure 4).

Table 2. Change in performance variables (M+SD)

	Pre	Post	% Change
PPO (Watts)			
TT	207±51.6	214±48.1	+3.2
VO_2	202±49.8	212±50.9[a]	+4.9
HR_{max} (bpm)	189±6.0	188±4.2	-0.5
VO_{2max} (L/min)	3.3±0.87	3.4±0.85	+3.0
VO_{2max} (ml/kg/min)	43.0±9.04	44.0±9.52	+2.3
VT (Watts)	116±40.3	134±32.4[a]	+15.5
EQ TT (Watts)	125+40.8	135+29.8	+8.0[b]

Note. [a]Significantly different than pre-test ($p<.05$).
[b]Significantly less vs. change in VT.

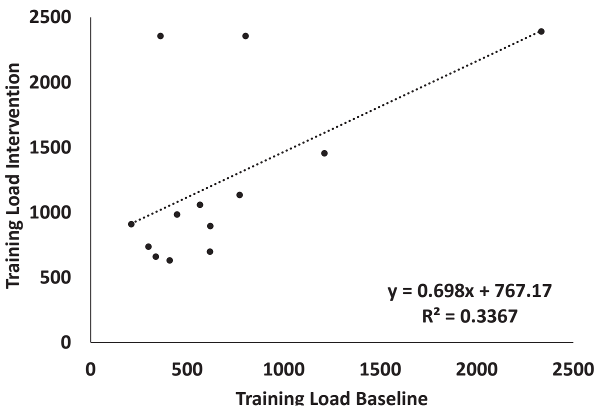

Figure 1. Comparison of training load (volume x intensity) from baseline through the 6 weeks of intervention.

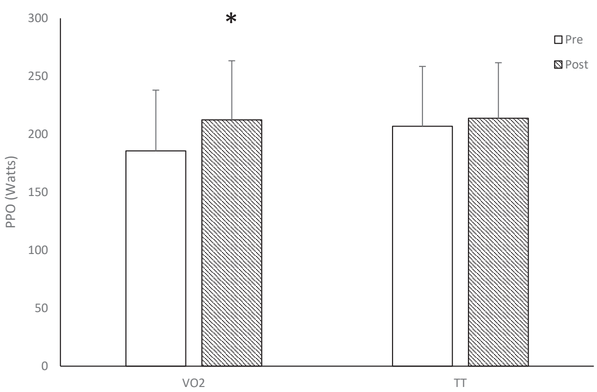

Figure 2. Comparison of changes in peak power output (Watts) from pre- to post-intervention between the VO_2max test and Talk Test. (M±SD)
** Significantly different than pre- and post-test for the VO_2max test.*

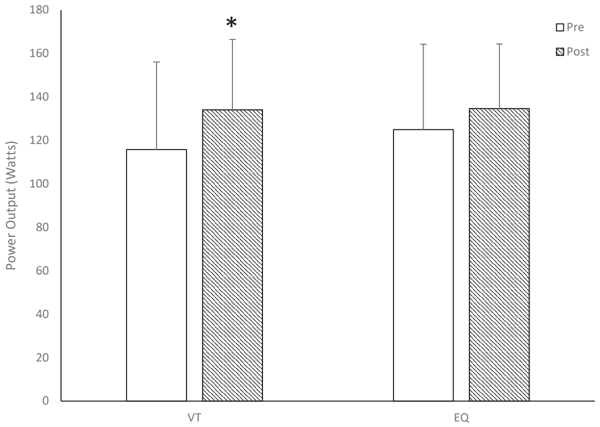

Figure 3. Changes from pre- to post-test VT and EQ stage of the TT PO (M±SD).
**Significantly different than pre-test PO (p<.05).*

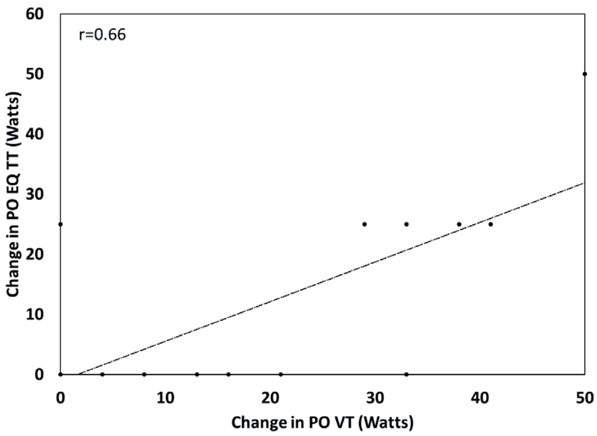

Figure 4. Comparison of change in power output at the EQ stage of the TT and VT from pre- to post-intervention.

Discussion and conclusion

The main finding of this study was that the simple device of the PO at the EQ stage of the TT tracks training induced changes in the PO at VT. However, using PO at the EQ stage of the TT tends to underestimate the magnitude of improvement in the PO at VT. The TT is a simple method of evaluating exercise capacity (Foster, et al. 2018). However, unlike directly measured VT, which is based on the measured VO_2, and which can be interpolated within stages, the TT is categorical in nature. This means that data are only collected at the end of each stage in the TT, and may be insensitive to small changes in PO at VT. This difference can limit the precision of detecting changes attributable to interventions, and bias toward underestimation of the magnitude of improvement. Participants often reached their VT during the middle of exercise stages, which can be accounted for by interpolating of the effective PO within a stage but could not be detected by the TT until the stage was complete. The protocol was based on previous studies with the TT (Foster, et al., 2018) with 25 Watt increments and three-minute stage duration. Stages of at least two-minutes duration are required to allow the increase in end-tidal CO_2, which is the mechanistic driver of the TT, to recover (Creemers, Foster, Porcari, Cress, & de Koning, 2017). While it is fairly clear that three-minute stages are somewhat more effective in cross-sectional evaluations, the typically small magnitude of changes in exercise capacity in well-trained individuals may necessitate shorter stage increments (~2 minutes) or smaller increments (~10 Watts) to allow for resolution of improvement in intervention studies.

The TT has been shown to be a valuable tool for guiding exercise training as well. Porcari et al. (2018) showed that exercise capacity improved, when measured by both VO_2max and PO (Watts), regardless of whether training was guided by the %HRR method or by the TT. Participants in the TT group tended to exercise between 70-75% HRR, which is within the recommended zone according to the ACSM guidelines (2017). However, this study failed to provide, in previously sedentary individuals, evidence of how well the PO at VT and the PO at the EQ stage of the TT corresponded.

There were several limitations to this study. The participants did not go through a familiarization with the VO_2max test or TT prior to the study. This decision was made due to our wide experience with the technique (Foster, et al., 2018) and the demonstrated reproducibility of the TT (Ballweg, et al., 2013), which suggested that eliminating a familiarization session was not likely to influence the results.

Despite being read the instructions for conducting the TT, some participants reported they were still able to talk comfortably when the investigator felt they could no longer talk. Lyon et al. (2014) found that participants reported to the clinician that they were still able to speak even though the clinician felt the participant had reached the EQ stage of the TT. In cardiac patients, Petersen, Maribo, Hjortdal, and Laustsen (2014) observed low reliability for the PO at the EQ stage of the TT when two or more therapists administered the TT. However, in the present study, all exercise tests were administered by the same investigator.

Another limitation is the self-reported RPE during the training period. Each participant was familiarized with the RPE scale prior to the study as a means of recording their intensity during the baseline assessment and training period. If the participant failed to look at the RPE scale following a training session, he/she may have underestimated exercise intensity (Loose, et al., 2012; Reed & Pipe, 2014). However, as all the participants used the RPE scale during pre-testing, it seems likely that they were habituated to the scale. Further, the wide-use of the sRPE method supports its robustness as a tool for monitoring exercise training (Foster, Rodriguez-Marroyo, & de Koning, 2017).

In conclusion, the present data suggests that the TT may be somewhat insensitive to changes in VT at the EQ stage due to the categorical nature of the TT. Participants may increase their VT between stages resulting in improvement not seen in the TT as participants are asked at the end of each stage if they are able to speak comfortably. Despite this flaw, both the TT and test performed using open circuit-spirometry showed improvement. Although, the EQ stage of the TT did not show significant increases between pre and post due to its design, PO found at the EQ stage of the TT was not significantly different than the PO at VT. Therefore, the TT can still be used as a less-expensive tool for analyzing change in performance over time.

References

American College of Sports Medicine. (2017). *ACSM's guidelines for exercise testing and prescription* (10th ed.). Philadelphia, PA: Wolters Kluwer Health.

Ballweg, J., Foster, C., Porcari, J.P., Haible, S., Aminaka, N., & Mikat, R.P. (2013). Reliability of the Talk Test as a surrogate of ventilatory and respiratory compensation thresholds [Letter to the editor]. *Journal of Sports Science and Medicine*, *12*, 610-611.

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

Borg, G. (1998). *Borg's perceived exertion and pain scales.* Champaign, IL: Human Kinetics.

Creemers, N., Foster, C., Porcari, J.P., Cress, M.L., & de Koning, J.J. (2017). The physiological mechanism behind the Talk Test. *Kinesiology, 49*, 3-8.

Foster, C., & Cotter, H.M. (2005). Blood lactate, respiratory and heart rate markers on the capacity for sustained exercise. In P.J. Maud & C. Foster (Eds.), *Physiological assessment of human fitness*, 2nd ed. (pp 63-76). Champaign, IL: Human Kinetics.

Foster, C., Florhaug, J.A., Franklin, J., Gottschall, L., Hrovatin, L.A., Parker, S., Doleshal, P., & Dodge, C. (2001). A new approach to monitoring exercise training. *Journal of Strength and Conditioning Research*, *15*(1), 109-115.

Foster, C., Hector, L.L., Welsh, R., Schrager, M., Green, M.A., & Snyder, A.C. (1995). Effects of specific vs cross training on running performance. *European Journal of Applied Physiology, 70*, 367-372.

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

Foster, C., Porcari, J.P., Ault, S., Doro, K., Dubiel, J., Engen, M., Kolman, D., & Xiong, S. (2018). Exercise prescription when there is no exercise test: The Talk Test. *Kinesiology*, *50*(1), 1-16.

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

Foster, C., Rodriguez-Marroyo, J.A., & de Koning, J.J. (2017). Monitoring training loads: The past, the present and the future. *International Journal of Sports Physiology and Performance, 12*(2): S2-2-S2-8. doi: 10.1123/IJSPP.2016-0388

Goode, R.C. (2008). Historical perspectives: A personal insight into the origin of the "Talk Test". *Health and Fitness Journal of Canada*, *1*(1), 5-8.

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

Gron Nielsen, S., Buus, L., Hage, T., Olsen, H., Walsoe, M., & Vinther, A. (2014). The graded cycling test combined with the Talk Test is reliable for patients with ischemic heart disease. *Journal of Cardiopulmonary Rehabilitation and Prevention*, *34*, 276-280. doi: 10.1097/HCR.0000000000000067

Katch, V., Weltman, A., Sady, S., & Freedson, P. (1978). Validity of the relative percent concept for equating training intensity. *European Journal of Applied Physiology and Occupational Physiology, 39*, 219-227.

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

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

Marx, A.J., Porcari, J.P., Doberstein, S., Arney, B.E., Bramwell, S., & Foster, C. (2018). The accuracy of heart rate-based zone training using predicted versus measured maximal heart rate. *International Journal of Research in Exercise Physiology*, *13*(1), 21-28.

Mezzani, A., Hamm, L.F., Jones, A.M., McBride, P.E., Moholdt, T., Stone, J.A., Urhausen, A., & Williams, M.A. (2012). Aerobic exercise intensity and assessment and prescription in cardiac rehabilitation: A joint position statement of the European Association for Cardiovascular Prevention and Rehabilitation, the American Association of Cardiovascular and Pulmonary Rehabilitation, and the Canadian Association of Cardiac Rehabilitation. *Journal of Cardiopulmonary Rehabilitation and Prevention*, *32*, 327-350.

Porcari, J.P., Falck-Wiese, K., Suckow-Stenger, S., Turek, J., Wargowsky, A., Cress, M.L., Doberstein, S.T., Hahn, C.J., Ryskey, A.L., & Foster, C. (2018). Comparison of the TT and percent heart rate reserve for exercise prescription. *Kinesiology, 50(1),* 1-8.

Petersen, A.K., Maribo, T., Hjortdal, V.E., & Laustsen, S. (2014). Intertester reliability of the Talk Test in a cardiac rehabilitation population. *Journal of Cardiopulmonary Rehabilitation and Prevention*, *34*(1), 49-53. doi: 10.1097/HCR.0000000000000029

Recalde, P.T., Foster, C., Skemp-Arit, K.M., Fater, D.C.W., Neese, C.A., Dodge, C., & Porcari, J.P. (2002). The 'Talk Test' as a simple marker of ventilatory threshold. *South African Journal of Sports Medicine*, *9*, 5-8.

Reed, J.L., & Pipe, A.L. (2014). The Talk Test: A useful tool for prescribing and monitoring exercise intensity. *Current Opinion in Cardiology*, *29*, 1-6. doi: 10.1097/HCO.0000000000000097

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

Scharhag-Rosenberger, F., Meyer, T., Gäßler, N., Faude, O., & Kindermann, W. (2010). Exercise at given percentages of VO2max: Heterogeneous metabolic response between individuals. *Journal of Science and Medicine in Sport, 13*, 74-79.

Seiler S. (2010). What is the best practice for training intensity and duration distribution in endurance athletes? *International Journal of Sports Physiology and Performance*, *5*, 276-291.

Voelker, S.A., Foster, C., Porcari, J.P., Skemp, K.M., Brice, G., & Backes, R. (2002). Relationship between the Talk Test and ventilatory threshold in cardiac patients. *Clinical Exercise Physiology*, *4*(2), 120-123.

Woltmann, M.L., Foster, C., Porcari, J.P., Camic, C.L., Dodge, C., Haible, S., & Mikat, R.P. (2015). Evidence that the Talk Test can be used to regulate exercise intensity. *Journal of Strength and Conditioning Research*, *29*(5), 1248-1254.

Zanettini, R., Centelghe, P., Franzelli, C., Mori, I., Benna, S., Penati, C., & Sorlini, N. (2012). Validity of the Talk Test for exercise prescription after myocardial revascularization. *European Journal of Preventative Cardiology*, *20*(2), 376-382. doi: 10.1177/20047487312438982

Submitted: February 23, 2019
Accepted: July 23, 2020
Published Online First: October 15, 2020

Correspondence to:
Kristen Deal, M.Sc.
Department of Kinesiology
University of Wisconsin-Milwaukee
Milwaukee, WI 53211 USA
Phone: (414) 229-4392
E-mail: kdeal@uwm.edu