J. Phys. Ther. Sci. 30: 933–937, 2018

The Journal of Physical Therapy Science

Original Article

Effects of incremental cardiorespiratory exercise on the speech rate and the estimated exercise intensity using the counting talk test

Siti Ruzita Mahmod, PT, MPhil[1)], Leela T Narayanan, PT, PhD[1)*], Eko Supriyanto, PhD[2)]

[1)] *Department of Clinical Science, Faculty of Bioscience and Medical Engineering, Universiti Teknologi Malaysia: 81310 Johor Bahru, Malaysia*
[2)] *IJN-UTM Cardiovascular Engineering Centre, Faculty of Biosciences and Medical Engineering, Universiti Teknologi Malaysia, Malaysia*

Abstract. [Purpose] This study examined how incremental cardiorespiratory exercise may affect the speech rate and Counting Talk Test (CTT)-estimated exercise intensity. [Participants and Methods] Twenty-four healthy adults performed the CTT while exercising on a treadmill at 6 stages of incremental exercise ranging from 40% to 85% of heart rate reserve (HRR). Each participant started walking on the treadmill at 3 to 4 km/h and 0% elevation to warm up. The increments of treadmill grades were adjusted until targeted heart rates corresponding to the percentages of HRR were reached. Then, the participants were asked to rate their perceived exertion while the treadmill grades were maintained for 2-minutes bouts of each exercise stage. At the last minute of the exercise stage, the CTT was performed within a single breath. [Results] The speech rates in the CTT appeared to vary significantly during exercise. Moreover, the CTT-estimated exercise intensity showed significant reductions at several exercise stages. [Conclusion] The CTT estimates exercise intensity semi-quantitatively throughout incremental exercise. However, moderate and vigorous intensities could not be significantly delineated by the current CTT method. This could be due to the variability in speech rates that were indicated as the exercise progressed.
Key words: Exercise intensity, Talk Test, Cardiorespiratory

(This article was submitted Feb. 17, 2018, and was accepted Apr. 25, 2018)

INTRODUCTION

The Talk Test (TT) is a useful and simple method for monitoring and prescribing exercise intensity[1, 2)] in both clinical[3–6)] and non-clinical populations[7–11)]. The TT is based on an assessment of the ability to carry on a conversation during cardiorespiratory exercise[12)]. This concept was introduced by Professor John Grayson in 1939, when he told British mountaineers to “climb no faster than you can speak”. This concept of vocalization while exercising at one’s own volition, creates a competition between breathing patterns required for linguistic phrasing and exercising[13)]. As a result, the ability to vocalize comfortably is compromised because cardiorespiratory exercise intensity exceeded the ventilatory threshold[10, 14–16)]. In this regard, various standard passage-based TT including the Pledge of Allegiance[4, 8, 10, 14, 17)], a nineteenth article of the Italian Constitution[6)], and a Danish text passage[18)], have been used for monitoring and prescribing the cardiorespiratory exercise intensity. These variations of the TT were used to estimate exercise intensity corresponding to the changes in cardiorespiratory exertion based on participants’ responses to their perceived comfort as they recite the passages while exercising. Three possible responses of either “yes”, “not sure” or “no” were assessed at several stages of progressive incremental exercise until a ventilatory threshold or beyond the threshold. Another variation of the TT introduced a counting technique, a semi-quantitative estimation of exercise intensity. This Counting Talk Test (CTT) required participants to count alouds using

*Corresponding author. Leela T Narayanan (E-mail: aqilah@biomedical.utm.my)

Table 1. Physical characteristics of the participants

Details	
Gender (Male/Female)	8/8
Age (years)	25.1 ± 3.9
Weight (kg)	64.7 ± 17.7
Height (cm)	160.0 ± 10.0
Body mass index (kgm^{-2})	23.3 ± 4.3
Resting respiratory rate (breaths min^{-1})	17 ± 3
Resting heart rate (beats min^{-1})	80 ± 7
Maximal inspiratory volume (ml)	2,600 ± 1,000

lexical repetitions such as one-one thousand, two-one thousand, three-one thousand, and so on within a single breath. The exercise intensity was estimated as the percentage of CTT (%CTT), which refers to the ratio between the numbers of counts per breath achieved while exercising and the count per breath at rest[11, 19]. The procedure required individuals to count aloud at their "usual" or "normal" pace, which may be subject to intra-individual and inter-individual variations. Although the counts at rest during the CTT were found to be consistent across sessions[11], the speech rate during the CTT performance in each session has not been established.

Utterance production is a rhythmic activity that tends to vary in its temporal structure even in highly fluent speakers[20], and it was found to be strongly associated with pulmonary ventilation and oxygen consumption[21]. Thus, changes in the speech rate should be considered during the TT performance either at rest or exercise condition, as they may indicate a different interpretation. The speech rate is the total number of syllables divided by speech duration including pauses[22], and a previous study has shown that pre-determined speech rate of 60–70 words/minute during exercising resulted in a consistent reduction of minute ventilation as exercise intensity increased[23]. Moreover, the metabolic needs significantly outweighed the linguistic phrasing at an exercise intensity corresponding to 75% of the maximal oxygen consumption[13], as a high level of ventilatory control is necessary for reasonably normal utterance at a higher exercise intensity[24, 25].

However, there is a lack of research concerning the effect of incremental exercise intensity on utterance in the CTT. Therefore, the present study was conducted to investigate how incremental cardiorespiratory exercise may affect the speech rate and CTT-estimated exercise intensity.

PARTICIPANTS AND METHODS

Twenty-four healthy participants with a mean age of 25.1 ± 3.9 years were recruited from Universiti Teknologi Malaysia, Johor Bahru for this study (Table 1). The inclusion criteria were as follows: healthy men and women aged between 19 and 35 years and those who were able to ambulate independently on a treadmill. Participants who had respiratory, speech or hearing problems, neurological disorders, and answered "yes" to any of the questions in the Physical Activity Readiness Questionnaire were excluded from this study. This study was approved by the Medical Research Ethics Committee, Ministry of Health Malaysia regarding research with humans (approval number NMRR-15-1614-27729). The test procedures were explained to the participants, and written informed consent was obtained from each of them before conducting the experiment.

The experiment was performed at the Cardiorespiratory Physiotherapy Laboratory. The participants were required to perform the CTT while exercising on a motorized treadmill (Track Motion, Kettler, Ense, Germany) at incremental stages ranging from 40% to 85% heart rate reserve (HRR)[11]. The experiment took approximately 1 hour and 15 minutes to complete and was comprised of an assessment, preparation of the participants, and exercise testing. The participants were informed earlier to refrain from eating at least 2 hours before attending the experiment. The participants were closely monitored by a physical therapist throughout the experiment. Initially, the participants were asked to rest in a half-lying position on an adjustable couch while 12-torso-positioned lead electrocardiograph electrodes[26], a pulse oximetry, and blood pressure cuff were attached to them. Baseline assessments of the participants' heart rate (HRrest) respiratory rate, oxygen saturation, and blood pressure were noted after 5 minutes of rest. Then, each participant's maximal heart rate (HRmax) was estimated based on the age-predicted maximum heart rate in the HRR equation ($208 - 0.7 \times age$)[27], while the targeted heart rates during the exercise stages at 40%, 50%, 60%, 70%, 80%, and 85% HRR were calculated using the following equation: [HRR (beats min^{-1})=exercise stages (%) × (HRmax − HRrest) + HRrest][28]. Next, the participants were provided with a wireless headset microphone (Rapoo H8030, Shenzen, China), and they were instructed to attach a safety clip on the treadmill before the exercise. The participants could request to stop the exercise test if they felt uncomfortable and felt that they were unable to complete the test safely, particularly those who experienced any deteriorating signs or symptoms, such as decreased oxygen saturation less than 85%, persistent irregular heartbeat, muscle cramps, or dizziness. Moreover, the standardized instructions for the Borg 6–20 RPE category scale and the CTT, which were audible from the headphone, were reviewed for the participants to confirm their understanding of the instructions. The Borg 6–20 RPE chart and the CTT transcript were

Table 2. The effects of incremental cardiorespiratory exercise on the speech rates in the Counting Talk Test (CTT) and its estimated exercise intensity

Stages of exercise	Intensity category	Speech rates (syllables/s)	%COV values for speech rates	CTT-estimated exercise intensity (%CTT)
Rest (baseline)		4.8 ± 0.5	10.4	100
40% HRR	Moderate	5.2 ± 0.6*	11.5	63*ǂ
50% HRR	Moderate	5.3 ± 0.6*	11.3	52*ǂ
60% HRR	Vigorous	5.4 ± 0.4*	7.4	47*
70% HRR	Vigorous	5.4 ± 0.8*	14.8	40*ǂ
80% HRR	Vigorous	5.3 ± 0.7*	13.2	36*
85% HRR	Vigorous	5.2 ± 1.0*	19.2	31*

Values are presented as the mean ± SD.
*Significant difference from the rest (baseline) value, p<0.05.
ǂSignificant difference from the former stage of exercise, p<0.05.
%HRR: percentage of the heart rate reserve; CTT: counting talk test; %COV: percentage of the coefficient of variability values.

affixed to a wall in front of the participants, approximately 90 cm away.

During the exercise testing, each participant started walking on the treadmill at 3 to 4 km/h and 0% elevation for 3 minutes as a warm-up phase. Then, the treadmill grades were increased by adjusting the speed within a range of 1 to 4 km/h as tolerated by the participants, and gradient of 1% until steady-state targeted heart rates corresponding to 40%, 50%, 60%, 70%, 80% and 85% HRR were reached. At each stage of the exercise, the participants were asked to rate their perceived exertion based on the Borg 6–20 RPE category scale while the speed and gradient were maintained for 2-minute bouts of each exercise stage. At the last minute of each exercise stage, they were also asked to perform the CTT immediately upon hearing the cue "take a deep breath in now and start counting". They were reminded to stop their utterances before taking a second breath. Further, the participants' respiratory rate, oxygen saturation, and heart rate and rhythm were monitored throughout the exercise tests using a portable patient monitoring system (IntelliVue MX450, Philips, Böblingen, Germany). The CTTs were recorded during the last minute of each bout of the exercise stages, and the CTT-estimated exercise intensity was calculated as $\%CTT=(CTT_{exercise}/\ CTT_{rest}) \times 100$, where $CTT_{exercise}$ was the CTT score during exercise stages and CTT_{rest} was the CTT score obtained at resting stage, before exercise[19].

Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) software (version 16.0; SPSS Inc., Chicago, IL, USA). The effects of 7 exercise stages (including the resting stage) on the speech rate and estimated exercise intensity using the CTT were analyzed using a two-way repeated measure of analysis of variance. The level of significance was set at p<0.05. Moreover, patterns of variability for the speech rates were calculated from all participants using coefficient of variance values as follows: SD / mean ×100.

RESULTS

Table 2 shows that the CTT speech rates varied from 4.8 to 5.4 syllables/s from resting stage and throughout the progressive incremental exercise stages, and the intensity of exercise appeared to have a significant effect on these utterances ($F_{[3.2, 72.5]}=5.796$, p=0.001). The speech rate demonstrated significant differences in all stages of exercise (p<0.05) when compared against the speech rate at baseline (i.e., resting stage). However, no significant changes in speech rates in the CTT were observed when a pairwise comparison was conducted between one stage of exercise to its subsequent stages.

Table 2 also demonstrates that %CTT decreased as the exercise progressed from lower %HRR to higher %HRR. From the resting state, the %CTT reduced significantly to 63% (p=0.00) at the exercise stage of 40%HRR. The %CTT also significantly reduced to 52% (p=0.004) at the exercise stage of 50%HRR, and to 40% (p=0.002) at the exercise stage of 70%HRR when compared against their former stages of exercise (i.e., 40% HRR and 60%HRR, respectively). However, no significant changes of %CTT were found between the exercise stages of 50% and 60% HRR, between 70% and 80% HRR, and between 80% and 85% HRR.

DISCUSSION

In our study, the significant increase of speech rates in all exercise stages when compared to the speech rate at the baseline state could be due to increased ventilatory oxygen demand[13, 29] for the speaking and exercise tasks. When both tasks were simultaneously performed, challenges in coordinating speaking and breathing, especially in a high respiratory drive condition[24], such as during progressive exercise, may disrupt the utterances. Moreover, a reduction in the ratio between the expiration time and total respiratory cycle time when participants were talking during exercise at incremental intensities[23) would be the underlying cause of the inconsistency of speech rates. This is because speech utterance production is limited during expiratory phases[23, 30], and in such competitive ventilatory requirements for simultaneous phonation and metabolic needs during exercise, non-phonated expirations may become dominant to remove excess carbon dioxide for important metabolite functions[24], thus making speaking difficult. Therefore, the speech rates in the CTT tended to be faster during exercise compared to the resting state.

Based on the results, exercise within 63% to 41% CTT corresponded to a moderate (i.e., 40% to 59% HRR) to vigorous (i.e., 60% to 89% HRR) exercise intensity[31]. Reduction of 22% in the %CTT occurred as participants exercised from 40% to 70% HRR, which may be due to high respiratory drive imposed by simultaneous exercises, thus decreasing the number of syllables per utterance and utterance duration[24]. From the resting state, the %CTT reduced significantly at the exercise stage of 40% HRR. Significant reductions were also observed in the %CTT at the exercise stages of 50% HRR, and 70% HRR when compared against their former stages of exercise (i.e., 40% HRR and 60%HRR, respectively). However, no significant changes of %CTT were found between exercise stages of 50% and 60% HRR, between 70% and 80% HRR, and between 80% and 85% HRR. These results have not been reported in any of previous studies related to the CTT[11, 19]. The exercise stages of 70% to 85% HRR were considered within the same category of vigorous intensity, according to the American College of Sports Medicine classification[31], and this was probably a reason why %CTT did not show significant changes as the participants exercised during those stages. The CTT approach could not distinguish each stage of incremental exercise for these study participants.

This study was limited to 24 healthy young adults, so it is difficult to generalize the findings of the present study to other populations in other age groups. Thus, additional studies should examine a broader sample to substantiate the findings of the present study. Additional studies should also examine how the TT can estimate exercise intensity quantitatively during incremental cardiorespiratory exercise with minimized variability of speech rate, which would ultimately strengthen the reliability of data.

Funding

This research was supported by the Science Fund, Ministry of Science and Technology, Malaysia 2017 (Project No: 01-01-06-SF1472).

Conflict of interest

None.

REFERENCES

1) Reed JL, Pipe AL: The talk test: a useful tool for prescribing and monitoring exercise intensity. Curr Opin Cardiol, 2014, 29: 475–480. [Medline] [CrossRef]
2) Webster AL, Aznar-Laín S: Intensity of physical activity and the 'Talk Test': a brief review and practical application. ACSM's Heal Fit J, 2008, 12: 13–17.
3) Brawner CA, Keteyian SJ, Czaplicki TE: A method of guiding exercise intensity: the Talk Test. Med Sci Sports Exerc, 1995, 27: 241. [CrossRef]
4) Brawner CA, Vanzant MA, Ehrman JK, et al.: Guiding exercise using the talk test among patients with coronary artery disease. J Cardiopulm Rehabil, 2006, 26: 72–75, quiz 76–77. [Medline] [CrossRef]
5) Cowan RE, Ginnity KL, Kressler J, et al.: Assessment of the talk test and rating of perceived exertion for exercise intensity prescription in persons with paraplegia. Top Spinal Cord Inj Rehabil, 2012, 18: 212–219. [Medline] [CrossRef]
6) Zanettini R, Centeleghe P, Franzelli C, et al.: Validity of the Talk Test for exercise prescription after myocardial revascularization. Eur J Prev Cardiol, 2013, 20: 376–382. [Medline] [CrossRef]
7) Norman JF, Kracl J, Parker D, et al.: Comparison of the Counting Talk Test and heart rate reserve methods for estimating exercise intensity in healthy young adults. J. Exerc. Physiol, 2002, 1: 15–22.
8) Persinger R, Foster C, Gibson M, et al.: Consistency of the talk test for exercise prescription. Med Sci Sports Exerc, 2004, 36: 1632–1636. [Medline]
9) Foster C, Porcari JP, Gibson M, et al.: Translation of submaximal exercise test responses to exercise prescription using the Talk Test. J Strength Cond Res, 2009, 23: 2425–2429. [Medline] [CrossRef]
10) Quinn TJ, Coons BA: The Talk Test and its relationship with the ventilatory and lactate thresholds. J Sports Sci, 2011, 29: 1175–1182. [Medline] [CrossRef]
11) Loose BD, Christiansen AM, Smolczyk JE, et al.: Consistency of the counting talk test for exercise prescription. J Strength Cond Res, 2012, 26: 1701–1707. [Medline] [CrossRef]
12) Foster C, Porcari JP, Anderson J, et al.: The talk test as a marker of exercise training intensity. J Cardiopulm Rehabil Prev, 2008, 28: 24–30, quiz 31–32. [Medline] [CrossRef]
13) Baker SE, Hipp J, Alessio H: Ventilation and speech characteristics during submaximal aerobic exercise. J Speech Lang Hear Res, 2008, 51: 1203–1214. [Medline] [CrossRef]
14) Voelker SA: Relationship between the talk test and ventilatory threshold in cardiac patients. University of Wisconsin-La Crosse, Dissertation of master's degree, 2001.
15) Rodríguez-Marroyo JA, Villa JG, García-López J, et al.: Relationship between the talk test and ventilatory thresholds in well-trained cyclists. J Strength Cond Res, 2013, 27: 1942–1949. [Medline] [CrossRef]
16) Dehart-Beverley M: Relationship between the talk test and ventilatory threshold. University of Wisconsin-La Crosse, Dissertation of master's degree, 1999.
17) Jeanes EM, Foster C, Porcari JP, et al.: Translation of exercise testing to exercise prescription using the talk test. J Strength Cond Res, 2011, 25: 590–596.

[Medline] [CrossRef]
18) Nielsen SG, Buus L, Hage T, et al.: The graded cycling test combined with the talk test is reliable for patients with ischemic heart disease. J Cardiopulm Rehabil Prev, 2014, 34: 276–280. [Medline] [CrossRef]
19) Norman JF, Hopkins E, Crapo E: Validity of the counting talk test in comparison with standard methods of estimating exercise intensity in young healthy adults. J Cardiopulm Rehabil Prev, 2008, 28: 199–202. [Medline] [CrossRef]
20) Miller JL, Grosjean F, Lomanto C: Articulation rate and its variability in spontaneous speech: a reanalysis and some implications. Phonetica, 1984, 41: 215–225. [Medline] [CrossRef]
21) Rotstein A, Meckel Y, Inbar O: Perceived speech difficulty during exercise and its relation to exercise intensity and physiological responses. Eur J Appl Physiol, 2004, 92: 431–436. [Medline] [CrossRef]
22) de Jong NH, Wempe T: Praat script to detect syllable nuclei and measure speech rate automatically. Behav Res Methods, 2009, 41: 385–390. [Medline] [CrossRef]
23) Meckel Y, Rotstein A, Inbar O: The effects of speech production on physiologic responses during submaximal exercise. Med Sci Sports Exerc, 2002, 34: 1337–1343. [Medline] [CrossRef]
24) Bailey EF, Hoit JD: Speaking and breathing in high respiratory drive. J Speech Lang Hear Res, 2002, 45: 89–99. [Medline] [CrossRef]
25) Hoit JD, Lansing RW, Perona KE: Speaking-related dyspnea in healthy adults. J Speech Lang Hear Res, 2007, 50: 361–374. [Medline] [CrossRef]
26) Jowett NI, Turner AM, Cole A, et al.: Modified electrode placement must be recorded when performing 12-lead electrocardiograms. Postgrad Med J, 2005, 81: 122–125. [Medline] [CrossRef]
27) Tanaka H, Monahan KD, Seals DR: Age-predicted maximal heart rate revisited. J Am Coll Cardiol, 2001, 37: 153–156. [Medline] [CrossRef]
28) da Cunha FA, Farinatti PT, Midgley AW: Methodological and practical application issues in exercise prescription using the heart rate reserve and oxygen uptake reserve methods. J Sci Med Sport, 2011, 14: 46–57. [Medline] [CrossRef]
29) Dempsey JA, Romer L, Rodman J, et al.: Consequences of exercise-induced respiratory muscle work. Respir Physiol Neurobiol, 2006, 151: 242–250. [Medline] [CrossRef]
30) Creemers N, Foster C, Porcari JP, et al.: The physiological mechanism behind the talk test. Kinesiology, 2017, 49: 3–8. [CrossRef]
31) Ferguson B: ACSM's guidelines for exercise testing and prescription. Wolters Kluwer. Lippincott Williams & Wilkins, 2014.