Translation of Exercise Test Response to Training Intensity Using the Count Scale

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BACKGROUND: Exercise testing is recommended before prescribing individualized exercise intensity. However, there are few data demonstrating how exercise test responses are translated into individualized training intensity using a simple method. We previously developed a simple method to rate dyspnea called the count scale, including the count scale number (CSN) and count scale time. The purpose of this study was to assess the CSN for translation of exercise test response to training intensity. METHODS: Twenty-eight subjects (22 men and 6 women) with COPD age 66.6 ± 8.22 y participated in 2 exercise sessions. During the first session, in which exercise was guided by the heart rate, the CSN and heart rate were obtained (ie, CSN_1 and HR_1) while the heart rate was increased by 20% compared with the resting heart rate. During the second session, exercise was guided by the CSN. When the CSN was close to the CSN_1, the CSN and corresponding heart rate were recorded as CSN_2 and HR_2. Differences between CSN_1 and CSN_2 and between HR_1 and HR_2 were compared. The relationship between HR_1 and HR_2 was analyzed. Agreement between HR_1 and HR_2 was evaluated by Bland-Altman plots. RESULTS: No significant differences were seen between HR_1 and HR_2 (96 ± 11 and 97 ± 11, respectively; $P = .14$). A high correlation between HR_1 and HR_2 was found ($r = 0.932$, $P < .001$). The 95% CI for the difference between HR_1 and HR_2 was −1.2 to 8.5 beats/min. CONCLUSIONS: Exercise guided by the CSN alone could result in a given heart rate response, suggesting that the CSN is a simple and practical tool in translating exercise test results into individualized training intensity. With the CSN as the intensity indicator, patients can exercise safely and effectively. *Key words: exercise intensity; COPD; count scale; exercise testing; exercise training.* [Respir Care 2016;61(2):220–224. © 2016 Daedalus Enterprises]

Introduction

Exercise is an important part of rehabilitation for patients with COPD. In order to minimize adverse events and obtain greater cardiopulmonary benefits, it is important for patients to be guided to exercise at a proper exercise intensity, because COPD patients have various exercise risks depending on their age, lung function impairment, and the presence of co-morbidities.[1] Therefore, cardiopulmonary exercise testing is recommended before prescribing individualized exercise intensity.[2,3] A major challenge in clinical exercise prescription is how to translate the exercise test response into an individualized training intensity that is suitable for use in a home-based rehabilitation program.

Target heart rate, based on estimated or assessed peak heart rate, is the most widely used objective approach for prescribing exercise training intensity.[4,5] However, heart rate monitoring is impractical and inconvenient during home-based exercise for the majority of patients. The Borg scale for the ratings of perceived exertion and the talk test are widely used subjective methods. Although the Borg scale rating is self-reported and feasible, the subjects need to see the scale for rating during exercise. Furthermore, a

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Table 1. Baseline Characteristics of the Subjects

Characteristics	Values
Subjects	28
Sex	
Male	22
Female	6
Age, y	66 ± 8
FEV_1, L	1.53 ± 0.48
FEV_1, % predicted	56.9 ± 15.6
FEV_1/FVC, %	56.3 ± 9.9

Data are presented as *n* or as mean ± SD.

QUICK LOOK

Current knowledge

Exercise is an important part of rehabilitation for patients with COPD. In order to minimize adverse events and obtain greater cardiopulmonary benefits, it is important for patients to be guided to exercise at a proper intensity. A major challenge in clinical exercise prescription is how to transfer the exercise test response into an individualized training intensity suitable for home use.

What this paper contributes to our knowledge

In a group of COPD subjects, exercise intensity was measured by the count scale number and heart rate response. The count scale number is the highest number the patient can count to while exhaling after a maximal inspiration. In these subjects, exercise guided by the count scale number alone resulted in a desired heart rate response. The count scale number proved to be a practical tool in translating exercise test results into individualized training intensity.

study by Gondoni et al.[6] found that level of education, gender, and the use of diuretics significantly affected the Borg scale rating. The talk test is another simple method to rate exercise intensity, and studies have shown that the talk test is a surrogate for the ventilatory threshold [7,8]. However, there was considerable variability reported with the method,[7] and the talk test depends on the subjective experience of the patient and thus allows room for error.

We previously developed a new method to rate dyspnea called the count scale, in which subjects inhale maximally and then count from 1 to the maximum number they can reach in 1 breath while exhaling.[9] The count scale, including the count scale number (CSN) and count scale time, has been showed to be a sensitive reflection of exercise intensity. The purpose of this study was to assess the CSN for translation of a cycle ergometer exercise test response to training intensity during a treadmill walking task. We measured CSN and heart rate in 2 exercise sessions and hypothesized that the CSN corresponding to a target heart rate in the cycle ergometer would result in a similar heart rate response (ie, close to the target heart rate) in the treadmill walking session.

Methods

Subjects

Twenty-eight subjects (22 men, 6 women) with COPD age 66.6 ± 8.2 y participated in this study from January 2014 to July 2014. Their baseline data are shown in Table 1. All subjects were clinically stable and provided written informed consent. The study was approved by the ethics committee of Beijing Friendship Hospital.

Pulmonary Function Testing

Spirometry (MasterScreen CPX, CareFusion, San Diego, California) was performed in all subjects; FEV_1 and FVC were recorded. Procedures were carried out according to American Thoracic Society/European Respiratory Society standards.[10]

Count Scale

Subjects wore a nose clip and breathed through the mouth. After taking a maximal inspiration, they counted out the Arabic numbers from 1 to as high as they could (ie, 1, 2, 3…) in one breath while exhaling. Subjects were instructed to speak loudly enough to be heard, at their usual talking volume, and without pausing between counting numbers. The highest number they spoke was recorded as the CSN.

In the first session, subjects exercised on an electronically braked cycle ergometer (ER 900L, CareFusion). Heart rate was recorded via electrocardiogram. The exercise work rate began with 20 W and was increased by 10 W every 2 min until the heart rate was increased by 20% compared with the resting heart rate. While cycling at that work rate, subjects performed the count scale. The CSN was recorded as CSN_1, and the average heart rate during this period of measuring the CSN was recorded as HR_1. In the second session, 30 min later, subjects exercised on a treadmill. The treadmill speed began with 2 miles/h and was increased by 0.5 miles/h every 2 min. The subjects were asked to perform the count scale during the last 30 s of each exercise stage. When CSN was close to CSN_1 (ie, the difference was $< \pm 5$), the exercise test was terminated, and the CSN was recorded as CSN_2. The heart rate aver-

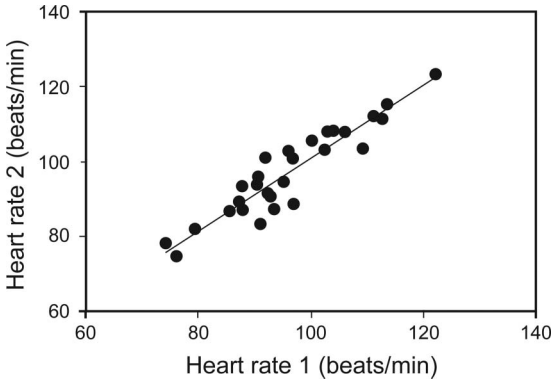

Fig. 1. Scatter plot of the correlation between HR_1 and HR_2 in subjects with COPD. HR_1 was the target heart rate. HR_2 was produced by the count scale number corresponding to HR_1. There was a highly significant correlation between HR_1 and HR_2 ($r = 0.932$; $P < .001$).

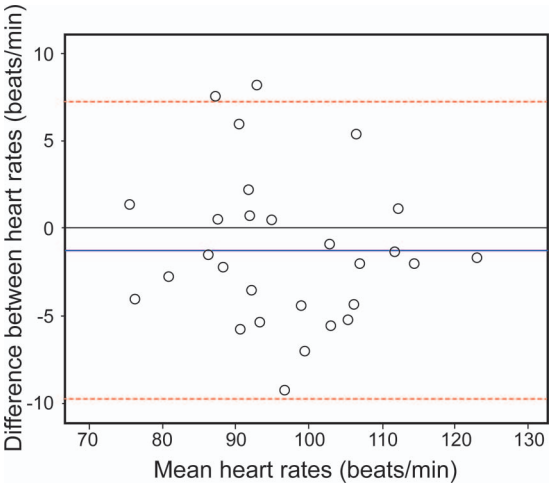

Fig. 2. Bland-Altman plot of difference in heart rate (target heart rate − responding heart rate) against the mean of the 2 heart rates. The 95% CI for the difference between the 2 heart rates was −1.2 to 8.5 beats/min. The blue line indicates a mean difference of −1.2, and red lines denote mean ± 1.96 SD.

aged for this period of measuring the CSN_2 was recorded as HR_2. The CSN and heart rate were recorded separately by 2 researchers. The subjects and the researcher responsible for testing the count scale were blinded to heart rate.

Statistical Analysis

Data are presented as mean ± SD. Differences between CSN_1 and CSN_2 and between HR_1 and HR_2 were examined using a paired-samples *t* test. Linear regression analysis was performed to assess the relationship between HR_1 and HR_2. Agreement between HR_1 and HR_2 was evaluated by Bland-Altman plots. $P < .05$ was considered statistically significant.

Results

Twenty-eight subjects with COPD were involved in this study. All subjects completed the CSN testing with no adverse events.

All data, including HR_1, HR_2, CSN_1, and CSN_2, were normally distributed. No significant differences were seen between CSN_1 and CSN_2 (26.7 ± 7.2 and 26.4 ± 7.4, respectively, $P = .53$) and between HR_1 and HR_2 (96 ± 11 and 97 ± 11 beats/min, respectively, $P = .14$). Figure 1 shows a highly significantly correlation between HR_1 and HR_2 ($r = 0.932$, $P < .001$). As shown in Figure 2, the 95% CI for the difference between HR_1 and HR_2 was −1.2 to 8.5 beats/min.

Discussion

Although our previous work has shown that the count scale is a simple and reproducible method for COPD subjects to measure dyspnea during exercise,[9] we have not previously studied how to translate exercise test response into training intensity using the count scale. Because exercise intensity is most often prescribed by using a target heart rate, we investigated the relationship between heart rate and CSN in subjects with COPD and found that exercise guided by the CSN corresponding to the target heart rate results in a heart rate that is similar to the target heart rate. The present study also indicated that the CSN was similar on different exercise modes when applying the same objective exercise intensity. This is the first study evaluating the validity of the count scale as a tool to translate exercise test response into a training intensity.

Although exercise training under supervision at the hospital is safe, home-based or community-based exercise training is the main way for the majority of stable patients to conduct pulmonary rehabilitation. Thus, it is important for patients to be instructed to exercise at a prescribed exercise intensity with a simple method. In this study, we designed 2 exercise sessions. In the first session, we measured the CSN at the target heart rate. In the second session, exercise was guided by the CSN, and we recorded the corresponding heart rate when the CSN was close to the CSN of the first session. There was no significant difference between the 2 heart rates, and the correlation was high ($r = 0.932$). The 95% CI for the difference between the target heart rate in the first session and the corresponding heart rate in the second session was relatively narrow (−1.2 to 8.5 beats/min), supporting the validity of the CSN as a tool for translating an exercise test response into a training intensity. It suggests that after we determine the target intensity in terms of V_{O_2}, because subjects are not allowed to speak during V_{O_2} measurement, we can measure the CSN at the target heart rate

corresponding to the target V_{O_2} in another session. Consequently, the individualized target intensity can be translated to corresponding CSN, and patients can guide their exercise intensity by themselves using the CSN.

The talk test is a subjective method recommended for prescribing exercise intensity on the basis of the subjects' ability to speak comfortably during exercise. Over the last decade, several studies evaluating the validity of the talk test have been published.[11-14] The talk test has been studied in healthy individuals and subjects with cardiovascular disease but not in subjects with chronic lung disease. Studies have shown that the talk test results in an exercise intensity that is near the ventilatory threshold, suggesting that the talk test may be a surrogate of the ventilatory threshold and can be used to prescribe exercise intensity not only for healthy adults[11] and athletes[15] but also for patients with coronary artery disease[7,12] when exercise test data are unavailable. However, the ventilatory threshold does not guarantee risk-free exercise, especially for patients with chronic lung disease. It follows that, when used as a surrogate for ventilatory threshold, the talk test will similarly not guarantee risk-free exercise. Brawner et al[7] showed that although the heart rate during exercise guided by the talk test was similar to the heart rate at ventilatory threshold, there was considerable variability (SD = 22–23% heart rate reserve), suggesting that the talk test has difficulty ensuring a safe exercise training intensity in each patient, especially in patients who may be at increased risk of adverse events during exercise. In the current study, the 95% CI for the difference between the target heart rate and the heart rate guided by the CSN was relatively narrow (−1.2 to 8.5 beats/min). The difference between the 2 heart rates was always < 10 beats/min. We think the error can be accepted in clinical practice.

In this study, we used number counting as a standard to gauge exercise intensity without any instruments. Any patient can be easily instructed to use it in any form of exercise training. The maximum number they can speak is inversely correlated with the intensity,[9] since it depends on the expiratory time, which is shortened when the respiratory rate increases during exercise.[16,17] Interestingly, this finding is very similar to a variation of the talk test, the counting talk test. Both the counting talk test and the count scale are semiquantitative tools and determine how high the patient can count before taking a second breath. The counting talk test has been shown to be useful in estimating exercise intensity in healthy adults.[18,19] However, the counting talk test must be performed at rest as well as at each intensity stage of exercise testing, and there have been as yet no reports in patients.

A limitation of this study is that we have only studied the relationship between CSN and the target heart rate at one exercise intensity (ie, heart rate increased by 20% compared with the resting heart rate). Further work needs to be done at higher exercise intensities.

Conclusions

We have demonstrated that the CSN is a simple and useful tool in prescription of exercise. After exercise intensity assessment, using the CSN, we could easily translate desired exercise intensity into corresponding training intensity using the CSN. Finally, with the CSN as the intensity indicator, patients can exercise safely and effectively.

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REFERENCES

1. Global Initiative for Chronic Obstructive Lung Disease. Global strategy for diagnosis, management, and prevention of COPD. http://www.goldcopd.org/guidelines-global-strategy-for-diagnosis-management.html. *Accessed August 12, 2015.*
2. Spruit MA, Singh SJ, Garvey C, ZuWallack R, Nici L, Rochester C, et al. An official American Thoracic Society/European Respiratory Society statement: key concepts and advances in pulmonary rehabilitation: an executive summary. Am J Respir Crit Care Med 2013;188(8):e13-e64.
3. Gloeckl R, Marinov B, Pitta F. Practical recommendations for exercise training in patients with COPD. Eur Respir Rev 2013;22(128):178-186.
4. Rotstein A, Meckel Y. Estimation of $\%VO_2$ reserve from heart rate during arm exercise and running. Eur J Appl Physiol 2000;83(6):545-550.
5. Mezzani A, Hamm LF, Jones AM, McBride PE, Moholdt T, Stone JA, et al. Aerobic exercise intensity 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. Eur J Prev Cardiol 2013;20(3):442-467.
6. Gondoni LA, Nibbio F, Caetani G, Augello G, Titon AM. What are we measuring? Considerations on subjective ratings of perceived exertion in obese patients for exercise prescription in cardiac rehabilitation programs. Int J Cardiol 2010;140(2):236-238.
7. Brawner CA, Vanzant MA, Ehrman JK, Foster C, Porcari JP, Kelso AJ, Keteyian SJ. Guiding exercise using the talk test among patients with coronary artery disease. J Cardiopulm Rehabil 2006;26(2):72-75.
8. Foster C, Porcari JP, Anderson J, Paulson M, Smaczny D, Webber H, et al. The talk test as a marker of exercise training intensity. J Cardiopulm Rehabil Prev 2008;28(1):24-30.
9. Wang HY, Xu QF, Yuan W, Nie S, He X, Zhang J, Kong YY, et al. A new method for rating dyspnea during exercise in patients with COPD. Chin Med J 2013;126(19):3616-3620.
10. Miller MR, Hankinson J, Brusasco V, Burgos F, Casaburi R, Coates A, et al. Standardisation of spirometry. Eur Respir J 2005;26(2):319-338.
11. Jeans EM, Jeans EA, Foster C, Porcari JP, Gibson M, Doberstein S. Translation of exercise testing to exercise prescription using the talk test. J Strength Cond Res 2011;25(3):590-596.

12. Zanettini R, Centeleghe P, Franzelli C, Mori I, Benna S, Penati C, Sorlini N. Validity of the talk test for exercise prescription after myocardial revascularization. Eur J Prev Cardiol 2013;20(2):376-382.
13. Reed JL, and Pipe AL. The talk test: a useful tool for prescribing and monitoring exercise intensity. Curr Opin Cardiol 2014;29(5):475-480.
14. Lyon E, Menke M, Foster C, Porcari JP, Gibson M, Bubbers T. Translation of incremental talk test responses to steady-state exercise training intensity. J Cardiopulm Rehabil Prev 2014;34(4):271-275.
15. Rodríguez-Marroyo JA, Villa JG, García-López J, Foster C. Relationship between the talk test and ventilatory thresholds in well-trained cyclists. J Strength Cond Res 2013;27(7):1942-1949.
16. O'Donnell DE, Bertley JC, Chau LKL, Webb KA. Qualitative aspects of exertional breathlessness in chronic airflow limitation: pathophysiologic mechanisms. Am J Respir Crit Care Med 1997;155(1):109-115.
17. Gelb AF, Gutierrez CA, Weisman IM, Newsom R, Taylor CF, Zamel N. Simplified detection of dynamic hyperinflation. Chest 2004;126(6):1855-1860.
18. 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(3):199-202.
19. Loose BD, Christiansen AM, Smolczyk JE, Roberts KL, Budziszewska A, Hollatz CG, Norman JF. Consistency of the counting talk test for exercise prescription. J Strength Cond Res 2012;26(6):1701-1707.