J. Phys. Ther. Sci. 32: 414–417, 2020

The Journal of Physical Therapy Science

Original Article

The effects of decreased inspiratory capacity on postural stability during backward reach

Akira Kubo, RPT, PhD[1)*], Masahiro Ishizaka, RPT, PhD[1)]

[1)] *Department of Physical Therapy, School of Health Sciences, International University of Health and Welfare: 2600-1 Kitakanemaru, Ohtawara-shi, Tochigi 324-8501, Japan*

Abstract. [Purpose] The purpose of this study is to investigate the effect of decreased inspiratory capacity on the backward reach distance in healthy young individuals, as patients with chronic obstructive pulmonary disease have a high risk of falling. [Participants and Methods] Thirteen healthy volunteers (age, 19.2 ± 0.4 years: mean ± SD) participated in this study. We recorded the backward reach distance at the resting expiration level and at two different inspiratory capacity levels: −1/3 and −2/3 of inspiratory capacity, when the air is inhaled at resting expiration level. We assessed the backward reach distance for each inspiratory capacity, using one-way repeated measures analysis of variance and post-hoc analysis. [Results] We found that inspiratory capacity has a significant effect on backward reach distance. The backward reach distance was significantly decreased in participants with a −2/3 inspiratory capacity, compared with the backward reach distance in participants with a resting expiration level. [Conclusion] Patients with lung volume fractionation and decreased inspiratory capacity lack postural stability during backward reach. Therefore, the link between decreased inspiratory capacity and loss of balance in patients with chronic obstructive pulmonary disease may, in part, be due to decreased postural stability, and the resulting tendency to plan movements, which create a loss of balance.

Key words: Inspiratory capacity, Backward reach, COPD

(This article was submitted Feb. 13, 2020, and was accepted Mar. 24, 2020)

INTRODUCTION

The inspiratory capacity (IC) and lung and rib cage elasticity decrease in patients with chronic obstructive pulmonary disease (COPD). The 6-minute walk test is the most commonly used test for rating the functional exercise capacity of patients with COPD. It measures four functional indicators: 6-minute walking distance (6MWD), self-perceived dyspnea, oxygen saturation, and heart rate. A 6MWD <350 m is considered the threshold for poor prognosis[1, 2)]. In addition to dyspnea during exercise, poor trunk mobility is one of the major disabilities in patients with COPD.

Loss of postural control is one of the most common comorbidities in elderly persons. Balance focuses on the complex integration of underlying central nervous system, and somatosensory and neuromuscular inputs. However, behaviors requiring balance naturally decrease with age. Therefore, certain conditions will be associated with more pronounced and rapid deterioration.

Impaired postural control more frequently occurs in elderly persons with COPD. Risk of fall is high in patients with COPD. Over the last 10 years, patients with COPD had difficulty in balancing[3, 4)]. However, little is known regarding the relationship between IC and balance impairment in patients with COPD. No study has investigated the relationship between balance and objectively measured IC.

Our previous study demonstrated that increased functional residual capacity might decrease the active range of thoracic axial rotation[5)] and a finger-floor distance[6)] in healthy young adults, though the causes and mechanisms of poor thoracic mo-

*Corresponding author. Akira Kubo (E-mail: akubo@iuhw.ac.jp)

bility in patients with COPD are complicated. These studies had limitations that required solving, i.e., IC was not measured using spirometry.

In this study, we hypothesize that a degree of decreased IC is associated with the risk of fall and balance disorder and could be a useful clinical tool for the assessment of patients with an emphysematous phenotype of COPD. Therefore, this study aimed to examine the effect of decreased IC as a risk factor of balance impairment based on backward reach with thoracic axial rotation.

PARTICIPANTS AND METHODS

Thirteen right-handed healthy male volunteers, recruited from the International University of Health and Welfare (age, 19.2 ± 0.4 years; height, 172.4 ± 5.5 cm; body weight, 64.6 ± 8.2 kg; body mass index, 21.8 ± 2.8 kg/m^2; mean ± standard deviation), participated in this study. The exclusion criteria were any pathologic condition of the spine, rib, shoulder, hip, or knee in the past 6 months, history of scoliosis, presence of spinal deformation, or rheumatologic or respiratory condition during the study period. All volunteers signed an informed consent form approved by the Institutional Review Board at the University of the corresponding author (Approval No. 2019-Io-1).

The experimental protocol is as follows; first, IC was measured in all participants and then backward reach was executed as far as possible without stepping.

IC was measured in sitting position using spirometry (AS-507, Minato Medical Science Co., Ltd., Tokyo, Japan) according to the recommended guidelines[7].

The experimental procedure of backward reach is shown in Fig. 1. To perform the backward reach test, the participant stood with their feet approximately shoulder-width apart and arms at their sides. The instrument (CK-101, SAKAI Medical Science Co., Ltd., Tokyo, Japan) was set up behind the participant's right upper extremity. The distance from the measuring instrument at the back of participant's right hand to the heel was the length of the right upper extremity (distance from acromion to the tip of the 3rd metacarpal bone).

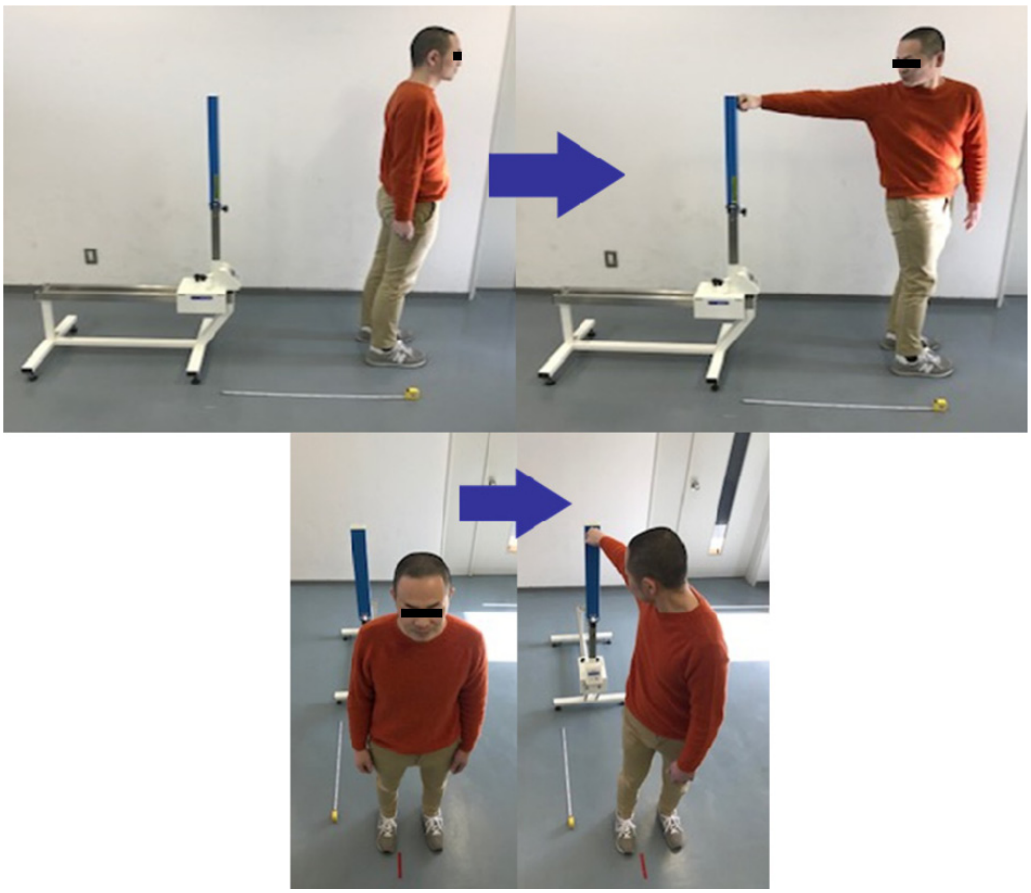

Fig. 1. The experimental procedure of backward reach.
The distance from the measuring instrument at the back of participant's right hand to the heel was the length of the right upper extremity (distance from acromion to the tip of the 3rd metacarpal bone).
The instrument was set up behind the participant's right upper extremity.

Fig. 2. 2,000-mL capacity graduated cylinder every 100 mL.

To measure reach distance, the participant was instructed to rotate the trunk clockwise and to extend the right hand backward as far as possible while maintaining the toes on the floor. The motion task was practiced several times. The backward reach distance was recorded at the resting expiration level and at two different IC levels: −1/3 and −2/3 IC air inhaled at the resting expiration level from a 2,000-mL capacity graduated cylinder every 100 mL (ACA105, Minato Medical Science Co. Ltd., Tokyo, Japan) (Fig. 2). Two repeated measures were acquired at each condition, and the average distance was calculated to determine the actual backward reach. Measurements of IC conditions were performed in a randomized order.

The distance of backward direction in three conditions at two IC conditions in addition to the resting expiration level was analyzed using a one-way repeated measure of ANOVA, and post-hoc analysis was carried out using Bonferroni's method. Statistical analysis of these results was conducted using SPSS for Windows 23.0 (IBM Corporation). Descriptive date are expressed as mean ± standard deviation. $P<0.05$ indicated statistical significance.

RESULTS

The distance of backward reach at resting expiratory, −1/3, and −2/3 IC was 18.9 ± 4.2 cm, 16.4 ± 4.4 cm, and 14.8 ± 4.8 cm, respectively. Significant effect ($p<0.01$) and difference were found between the resting expiratory and −2/3 IC ($p<0.05$).

DISCUSSION

This study confirmed that the backward reach distance was affected by IC and the degree of decreased IC was associated with balance disorder and risk of fall. Anami et al.[8] examined the relationships between the timed up and go (TUG) test, physical function tests, and the difference in balance activities relative to the severity in patients with COPD. The TUG score was significantly lower than the BODE index quartile, which stands for Body mass index, airflow Obstruction, Dyspnea and Exercise capacity, in the severe COPD group. Therefore, patients with COPD had decreased balance ability, which could lead to an increased risk of falls.

Although a balance assessment is now recommended by clinical practice guidelines for pulmonary rehabilitation, specific tests have yet to be suggested. Oliveira et al.[9] recommended the Berg Balance Scale, Balance Evaluation System test, and Activities-specific Balance Confidence score to assess balance in patients with COPD. However, many of these tests require longer time to perform and participants need to walk. In contrast, this backward reach method is simple and can be performed in a standing position. Therefore, this can be easily introduced in actual clinical setting.

Increased muscle activity to assist respiration and aging effects in addition to decreased IC in patients with COPD leads to poor postural stability due to the limitation of muscular and joint flexibility, including the rib cage. These factors simultaneously affect the postural stability. The study participants were healthy young men. Thus, this is the first study to demonstrate decreased postural stability with quantitatively decreased IC.

This study has some limitations. The number of participants was small and they only consisted of male participants. These limitations might have influenced the results of the present study. Therefore, our results should be interpreted carefully.

Finally, we found that decreased IC conditions tend to greatly lower the backward reach distance, as compared to the three IC conditions. Decreased inspiratory capacity may create loss of balance during the backward reach. This correlation might also be the case in patients with COPD. Furthermore, whether these findings can be applied to patients with COPD remains to be elucidated.

Conflict of interest

The authors declare no conflicts of interest in this work.

REFERENCES

1) Cote CG, Casanova C, Marín JM, et al.: Validation and comparison of reference equations for the 6-min walk distance test. Eur Respir J, 2008, 31: 571–578. [Medline] [CrossRef]
2) Spruit MA, Watkins ML, Edwards LD, et al. Evaluation of COPD Longitudinally to Identify Predictive Surrogate Endpoints (ECLIPSE) study investigators: Determinants of poor 6-min walking distance in patients with COPD: the ECLIPSE cohort. Respir Med, 2010, 104: 849–857. [Medline] [CrossRef]
3) Beauchamp MK, Hill K, Goldstein RS, et al.: Impairments in balance discriminate fallers from non-fallers in COPD. Respir Med, 2009, 103: 1885–1891. [Medline] [CrossRef]
4) Janssens L, Brumagne S, McConnell AK, et al.: Proprioceptive changes impair balance control in individuals with chronic obstructive pulmonary disease. PLoS One, 2013, 8: e57949. [Medline] [CrossRef]
5) Kubo A, Ishizaka M, Takeuchi Y, et al.: Effect of increased functional residual capacity on the active range of thoracic axial rotation in healthy young men. J Phys Ther Sci, 2018, 30: 282–285. [Medline] [CrossRef]
6) Takeuchi Y, Kato H, Ishizaka M, et al.: Effects of increased functional residual capacity on finger-floor distance in healthy young adults. J Phys Ther Sci, 2019, 31: 29–32. [Medline] [CrossRef]
7) Miller MR, Hankinson J, Brusasco V, et al. ATS/ERS Task Force: Standardisation of spirometry. Eur Respir J, 2005, 26: 319–338. [Medline] [CrossRef]
8) Anami K, Horie J, Shiranita S, et al.: A comparison of the timed up and go test across the severity of symptoms of BODE index in chronic obstructive pulmonary disease patients. Jpn J Health Promot Phys Ther, 2011, 1: 67–72 (in Japanese). [CrossRef]
9) Oliveira CC, Lee A, Granger CL, et al.: Postural control and fear of falling assessment in people with chronic obstructive pulmonary disease: a systematic review of instruments, international classification of functioning, disability and health linkage, and measurement properties. Arch Phys Med Rehabil, 2013, 94: 1784–1799.e7. [Medline] [CrossRef]