Changes in cardiopulmonary function in normal adults after the Rockport 1 mile walking test: a preliminary study

Kyoung Kim, PhD1), Hye-young Lee, PhD1), Do-youn Lee, MSc1), Chan-Woo Nam, MS1)*

1) Department of Physical Therapy, College of Rehabilitation Science, Daegu University: 201 Daegudae-ro, Gyeongsan-si, Gyeongsangbuk-do, Republic of Korea

Abstract. [Purpose] The purpose of this study was to investigate the changes of cardiopulmonary function in normal adults after the Rockport 1 mile walking test. [Subjects and Methods] University students (13 males and 27 females) participated in this study. Before and after the Rockport 1 mile walking test, pulmonary function, respiratory pressure, and maximal oxygen uptake were measured. [Results] Significant improvements in forced vital capacity and maximal inspiratory pressure were observed after the Rockport 1 mile walking test in males, and significant improvements in forced vital capacity, forced expiratory volume at 1 s, maximal inspiratory pressure, and maximal expiratory pressure were observed after the Rockport 1 mile walking test in females. However, the maximal oxygen uptake was not significantly different. [Conclusion] Our findings indicate that the Rockport 1 mile walking test changes cardiopulmonary function in males and females, and that it may improve cardiopulmonary function in middle-aged and older adults and provide basic data on cardiopulmonary endurance. Key words: Rockport 1 mile walking test, Aerobic fitness, Respiratory function

INTRODUCTION

Walking is generally perceived as a means of improving health and fitness, and is one of the most natural human motions1). Regular walking exercise can improve the mental state, muscle strength, and the ability to metabolize sugar by improving the insulin concentration in fat and the insulin response to blood sugar2). In addition, it has a positive effect on cardiovascular patients and reduces the risk of cardiovascular disease. Furthermore, it has been reported that walking-based exercises improve the activities of daily living and the quality of life of elderly people3).

Walking exercise increases respiration, which is a means of generating energy. Two muscle groups control respiration, namely inspiratory and expiratory muscles. The diaphragm and intercostal externi are agonists of inspiration for tidal breathing, and the synergistic muscles are the sternocleidomastoid, scalene, pectoralis major, pectoralis minor, and serratus anterior, which are activated during deep, forced, and labored breathing. Muscles related to expiration not activated during normal breathing but are activated during deep and forced breathing include the rectus abdominis, transverse abdominis, internal and external obliques, and intercostalis interni4).

“Aerobic” indicates energy generation by using oxygen, and aerobic exercise is active, durational, and rhythmic and has a substantial effect on cardiopulmonary endurance. Walking, jogging, skipping, aerobics, dancing, swimming, and cycling are all aerobic exercises that facilitate cardiopulmonary function because they require large amounts of oxygen to be supplied to the body5).

Walking exercise is efficient because it is an energy-consuming, convenient, and low-impact aerobic exercise, and is widely performed by people regardless of gender or age to improve health. Furthermore, it is safe; for example, it is prescribed as a low-impact exercise for the knee joints6).

The Rockport 1 mile walking test (RWT) is the most commonly used field test to assess cardiopulmonary fitness and provides a representative means of predicting aerobic fitness based on gender, age, body mass index, and heart rate information7). However, no study has yet investigated cardiopulmonary function after the RWT. Therefore, in this study, we measured pulmonary functions, respiratory pressures, and maximal oxygen uptake (VO2max) after the RWT, and investigated changes in cardiopulmonary competence in males and females.

SUBJECTS AND METHODS

Forty university students were recruited for this study. All subjects understood the purpose of this study and provided written informed consent before participation. This study was approved by the institutional review board of Daegu University. Recruited subjects with a diagnosis of cardiac
Pulmonary function, respiratory pressure, and VO$_2$max were measured after the RWT. Before the RWT, height and weight were measured by using a stadiometer (Biospace, Korea). To measure the VO$_2$max, heart rate was measured for 60 s immediately after the RWT. The formula used to calculate VO$_2$max was as follows\(^7\):

\[
\text{VO}_2\text{max} = 132.853 - (0.0769 \times \text{body weight in pounds}) - (0.3877 \times \text{age in years}) + (6.315 \times \text{sex score}) - (3.2649 \times \text{time in minutes to walk 1 mile}) - (0.1565 \times \text{heart rate at the end of the walk})
\]

For the sex score, males were given a score of 1 and females a score of 0. Walking time was calculated in minutes. Pulmonary function measures, such as forced vital capacity (FVC), forced expiratory volume at 1 s (FEV$_1$), FEV$_1$/FVC ratio, and peak expiratory flow (PEF), were measured after the RWT by using a portable spirometer (SpiroPALM; Cosmed, Italy). The subjects were instructed to sit on a chair in an upright posture and to exhale into a mouthpiece. The maximal air speed and volume at maximum inspiration were recorded. The maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP) were measured to determine the PImax values by using a respiratory pressure meter (MicroRPM; CareFusion, Ireland). Maximum inhalations and exhalations were performed in a comfortable sitting position. The RWT was performed on a treadmill after stretching and slow-walking practice. The participants were instructed to walk as fast as possible but not to run. The speed of the treadmill began at 0.5 mph and then was increased to 3.0 mph and to 3.5 mph. Perceived exertion (PE) was rated during the walk test.

Descriptive statistics were used to analyze the demographic data, and the paired t-test was used to compare differences between pre- and post-RWT. Statistical analysis was performed with the PASW ver. 18.0 statistical package (SPSS, Chicago, IL, USA), and statistical significance was accepted for p values <0.05.

**RESULTS**

The general characteristics of the 40 subjects are provided in Table 1. In males, the FVC and MIP significantly changed after the RWT; however, the FEV$_1$/FVC, MEP, and VO$_2$max did not. In females, the FVC, FEV$_1$/FVC, MIP, and MEP changed significantly after the RWT. In males and females, the VO$_2$max changed after the RWT; however, the difference was not significant (Table 2).

**DISCUSSION**

This study was undertaken to investigate the changes in cardiopulmonary functions, such as pulmonary function, respiratory pressure, and VO$_2$max, after the RWT. This test is not only useful for measuring cardiopulmonary efficiency but is also easily applied and requires little equipment. Furthermore, it can be used to predict cardiopulmonary endurance and physical fitness in all ages\(^8\).

Pulmonary function is commonly measured by evaluating the FVC, FEV$_1$, FEV$_1$/FVC, and PEF. The MIP and MEP are the most commonly used variables in assessing respiratory muscle pressure because they are easy to evaluate and the measurements have fewer adverse effects\(^9\). Respiratory competence has been widely used to diagnose and monitor pulmonary function and respiratory pressure in many studies\(^10, 11\).

In females, significant differences were observed for FEV$_1$/FVC and MEP after the RWT, which suggests that the RWT has positive effects on pulmonary function and respiratory pressure in both males and females. However, the VO$_2$max increased marginally and FVC significantly increased. This result is in line with the results of a previous randomized control study, in which treadmill gait exercise was performed for 30–45 min at 70–80% heart rate, by using the Naughton protocol in patients with pulmonary hypertension\(^12\). In addition, significant differences in FVC were reported after testing in another study that investigated the cardiopulmonary function of 13 children with cystic fibrosis after the 6-min walk test\(^13\).

We considered that the respiratory pressure was changed by the coactivations of respiratory muscles during the RWT, which is in line with the conclusion of a previous study that inspiratory muscle training and expiratory muscle training

### Table 1. General characteristics of the subjects

|                      | Males (n = 13) | Females (n = 27) |
|----------------------|----------------|------------------|
| Age (years)          | 25.9±5.0       | 22.1±0.6         |
| Height (cm)          | 174.7±5.5      | 161.6±5.0        |
| Weight (kg)          | 67.6±7.0       | 54.9±8.2         |

Values are expressed as mean ± SD

### Table 2. Comparison of changes in respiratory function and maximum oxygen uptake in men and women

|                      | Males (n = 13) | Females (n = 27) |
|----------------------|----------------|------------------|
| **Pre-RWT**          | **Post-RWT**   | **Pre-RWT**      | **Post-RWT**     |
| **Respiratory function** |                |                  |                  |
| FVC (l)              | 3.5±0.8        | 4.1±0.6*         | 2.4±0.4          | 2.7±0.4*          |
| FEV$_1$/FVC (%)      | 3.3±0.8        | 3.8±0.5          | 2.2±0.4          | 2.5±0.4*          |
| MIP (cmH$_2$O)       | 82.1±16.1      | 94.5±18.6*       | 53.0±15.7        | 67.0±21.4*        |
| MEP (cmH$_2$O)       | 75.6±24.4      | 84.4±26.9        | 52.2±13.9        | 65.4±22.4*        |
| VO$_2$max (mL·kg$^{-1}$·min$^{-1}$) | 45.2±12.1 | 53.8±7.2         | 42.8±11.3        | 43.7±11.4         |

Asterisk (*) indicates a significant change pre-to-post RWT at the p < 0.05 level.
help improve muscle strength and endurance by applying load to the diaphragm and accessory muscles. (14)

The VO2max is a more representative index of physical endurance than parameters such as pulmonary ventilatory capacity and cardiac output, and thus, it is widely used to investigate maximum exercise performance and cardiopulmonary endurance. The VO2max is defined as the maximum volume of oxygen that the human body can absorb per unit time during exercise. In addition, the relation between muscle activity and oxygen consumption is important and is widely used to analyze endurance because it provides a measure of oxygen transport. (15) In the present study, VO2max values were found to be nonsignificantly higher post-RWT, and we attribute this lack of significance to individual differences in muscle mass, gait pattern, and walking speed. It has been reported that mild aerobic exercise uses fat as a fuel, and thus, aids in weight maintenance. In a study that compared heavy- and mild-intensity exercises, no postexercise difference in body composition was observed in the heavy-exercise group, but a significant difference was noted in the mild-exercise group, which suggests that mild-intensity exercise is more effective at reducing body fat levels. Furthermore, it was found that the cardiovascular systems of females who performed mild-exercise programs improved as much as those who performed jogging and cycling exercises. (16, 17)

Physical activities and exercise consume energy and have a positive effect on health and physical fitness. Walking is an everyday activity, and can be performed safely in parks and living spaces. Regular walking can improve cardiopulmonary function and endurance and retard the progression of degenerative and metabolic diseases, in addition to its many social and psychological benefits. (19)

In this pilot study, the respiratory function after the RWT showed various changes, and it is believed that walking training may influence respiratory function and cardiopulmonary endurance in normal adults and in the elderly. Some limitations of this study should be considered. First, this study was performed with a single measurement design; thus, we cannot comment on long-term effects. Second, the number of subjects recruited was too small to allow drawing generalizations. Third, only young healthy male and female subjects were selected. Thus, further studies with middle-aged and elderly participants are needed to confirm the clinical associations identified in this study.

ACKNOWLEDGEMENT

This research was supported by a Daegu University research grant (2012).

REFERENCES

1) Zajac FE, Neptune RR, Kautz SA: Biomechanics and muscle coordination of human walking. Part I: introduction to concepts, power transfer, dynamics and simulations. Gait Posture, 2002, 16: 215–232. [Medline] [CrossRef]
2) Gudat U, Bunger S, Kummer F, et al.: The blood glucose lowering effects of exercise and glibenclamide in patients with type 2 diabetes mellitus. Diabet Med, 1998, 15: 194–198. [Medline] [CrossRef]
3) Fletcher GF, Balady GJ, Amsterdam EA, et al.: Exercise standards for testing and training: a statement for healthcare professionals from the American Heart Association. Circulation, 2001, 104: 1694–1740. [Medline] [CrossRef]
4) Kiens B, Colby LA: Therapeutic Exercise: Foundations and Techniques. Philadelphia: F.A. Davis Company, 2002.
5) Swain DP, Franklin BA: Comparison of cardioprotective benefits of vigorous versus moderate intensity aerobic exercise. Am J Cardiol, 2006, 97: 141–147. [Medline] [CrossRef]
6) Davison RC, Grant S: Is walking sufficient exercise for health? Sports Med, 1993, 16: 369–373. [Medline] [CrossRef]
7) Kline GM, Porcari JP, Hintermeister R, et al.: Estimation of VO2max from a one-mile track walk, gender, age, and body weight. Med Sci Sports Exerc, 1987, 19: 253–259. [Medline] [CrossRef]
8) American College of Sports Medicine: ACSM’s Guidelines for Exercise Testing and Prescription. Lippincott Williams & Wilkins, 2013.
9) American Thoracic Society/European Respiratory Society: ATS/ERS Statement on respiratory muscle testing. Am J Respir Crit Care Med, 2002, 166: 518–624. [Medline] [CrossRef]
10) Kwon YH, Lee HY: Differences in respiratory pressure and pulmonary function among children with spastic diplegic and hemiplegic cerebral palsy in comparison with normal controls. J Phys Ther Sci, 2015, 27: 401–403. [Medline] [CrossRef]
11) Lee HY, Kim K: Can walking ability enhance the effectiveness of breathing exercise in children with spastic cerebral palsy? J Phys Ther Sci, 2014, 26: 539–542. [Medline] [CrossRef]
12) Chan L, Chin LM, Kennedy M, et al.: Benefits of intensive treadmill exercise training on cardiorespiratory function and quality of life in patients with pulmonary hypertension. Chest, 2013, 143: 333–343. [Medline] [CrossRef]
13) Florêncio R, Fregonezi G, Brilhante S, et al.: Heart rate variability at rest and after the 6-minute walk test (6MWT) in children with cystic fibrosis. Braz J Phys Ther, 2013, 17: 419–426. [Medline]
14) Moodie L, Reever J, Elkins ME: Inspiratory muscle training increases inspiratory muscle strength in patients weaning from mechanical ventilation: a systematic review. J Physiother, 2011, 57: 213–221. [Medline] [CrossRef]
15) Impellizzeri FM, Marcorna SM, Castagna C, et al.: Physiological and performance effects of generic versus specific aerobic training in soccer players. Int J Sports Med, 2006, 27: 483–492. [Medline] [CrossRef]
16) Pollock ML, Gaesser GA, Butcher JD, et al.: American College of Sports Medicine Position Stand. The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness, and flexibility in healthy adults. Med Sci Sports Exerc, 1998, 30: 975–991. [Medline] [CrossRef]
17) Girandola RN: Body composition changes in women: effects of high and low exercise intensity. Arch Phys Med Rehabil, 1976, 57: 297–300. [Medline]
18) Morris JN, Hardman AE: Walking to health. Sports Med, 1997, 23: 306–332. [Medline] [CrossRef]
19) Kligman EW, Pepin E: Prescribing physical activity for older patients. Geriatrics, 1992, 47: 33–34, 37–44, 47. [Medline]