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Original Article

Utility of a Simple Expiratory Pressure Measurement Device in the Evaluation of Pulmonary Function

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SUMMARY

Background: Society is rapidly aging worldwide, and the incidence of chronic respiratory disease is increasing. Because spirometry requires specialized equipment and is not widely available, a technique that can easily and objectively evaluate pulmonary function is needed.
Methods: A total of 76 participants enrolled in the present study (29 in the healthy older group and 47 in the respiratory disease group). Pulmonary function data obtained with a conventional spirometer were compared with that obtained with a simple expiratory pressure measurement device.
Results: Significant differences in forced vital capacity (FVC), forced expiratory volume in 1 s (FEV_1), peak expiratory flow, and integration expiratory pressure were found between the groups. Strong correlations between integration expiratory pressure and FVC and between integration expiratory pressure and FEV_1 were noted in all participants.
Conclusions: The integration expiratory pressure values obtained by the simple expiratory pressure measurement device approximated the participants' FVC values from spirometry, suggesting that integration expiratory pressure values can predict decreases in FVC.

1. Introduction

The elderly population is growing rapidly worldwide, and the rate of aging is highest in Japan.[1] With the aging of the population, the incidence of chronic respiratory disease is increasing. The World Health Organization (WHO) predicts that respiratory diseases will comprise the third to the fifth most common causes of mortality by 2020.[2] Pneumonia has already become the third leading cause of mortality in Japan since 2013, and mortality due to aspiration pneumonia comprises 70% of these cases.

Using lung scintigraphy, Huxley and colleagues reported that half of the population aged 65 years or older experienced aspiration during sleep.[3] Nearly half of the population with dementia living in a medical treatment facility has experienced pneumonia or bronchitis, and 85.8% of these patients have experienced dysphagia.[4] Moreover, among the causes of mortality associated with dementia, respiratory disease was the cause of death in 55.5% and 33.1% of patients with Alzheimer's disease and vascular dementia, respectively.[5]

Similar to other skeletal muscles, respiratory muscles weaken with age. Decreased respiratory muscle strength can lead to dyspnea, pneumonia, and aspiration. In addition to ventilatory function, the respiratory muscles also perform non-ventilatory functions, such as coughing and swallowing, that require forced expiration. It has been reported that the expiratory muscle group is especially susceptible to the effects of aging.[6]

Orui and colleagues used spirometry to measure the vital capacity and forced expiratory volume in 1 s (FEV_1). The authors plotted these values in relation to age and found a significant decrease in vital capacity and forced expiratory volume due to aging in both male and female participants. In patients with obstructive pulmonary disease, expiratory values are reduced due to airway obstruction, which leads to a decrease in FEV_1 and lung capacity. In the case of restrictive pulmonary disease, lung expansion is limited, which decreases lung capacity.

Spirometry is used to evaluate pulmonary function, but its availability and use are insufficient. Moreover, the results of

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pulmonary function testing depend on the patient's ability to understand instructions and forcefully exhale during the examination. Spirometry is conventionally used to evaluate pulmonary function in healthy older people; however, it has been reported that reliably assessing pulmonary function is difficult owing to participants' unfamiliarity with the procedure,[7] and there is an urgent need for simpler methods to evaluate pulmonary function in light of the rapidly aging population.

The principal aims of the present study were to verify the correlation between data obtained from a simple expiratory pressure measurement device utilizing party horns and data obtained from spirometry. Based on these results, the ultimate goal was to examine the utility of the simple expiratory pressure measurement device as an easy and objective method to assess pulmonary function in healthy older people and patients with respiratory disease.

2. Materials and methods

2.1. Participants

A total of 76 participants (50 male and 26 female; mean age: 74.4 ± 10.0 years) participated in the present study. The healthy older group consisted of 29 healthy men and women aged 65 years or older who were registered with the Silver Human Resource Center (17 male and 12 female; mean age: 72.6 ± 5.8 years). The respiratory disease group consisted of 47 patients receiving treatment at the Respiratory Clinic (33 male and 14 female; mean age: 75.5 ± 11.8 years). Participants who could not provide written informed consent or who did not participate in all of the experimental sessions were excluded from the present study. The study was approved by the institutional review board of Nagasaki University.

2.2. Apparatus

The present study utilized a simple expiratory pressure measurement device (prototype of Science Research Co., Ltd., Nagasaki, Japan) (Fig. 1) and a spirometer (Spirometer 801, CHEST M.I., Inc., Tokyo, Japan).

Because there is a high degree of extension resistance when attempting to use the party horns for the first time, we used 45-cm party horns that had been completely expanded three times by the examiners before the beginning of the experiment. The disposable rigid tube and a 45-cm disposable party horn were inserted into a soft tube. The disposable rigid tube was held in the mouth, and the participants were instructed to inhale through the nose and exhale out the mouth as strongly and quickly as possible to completely extend the party horns. The expiratory pressure during expiration (sampling frequency: 30 times/second) was digitized by the white box of Fig. 1, and the data were saved to a tablet computer.

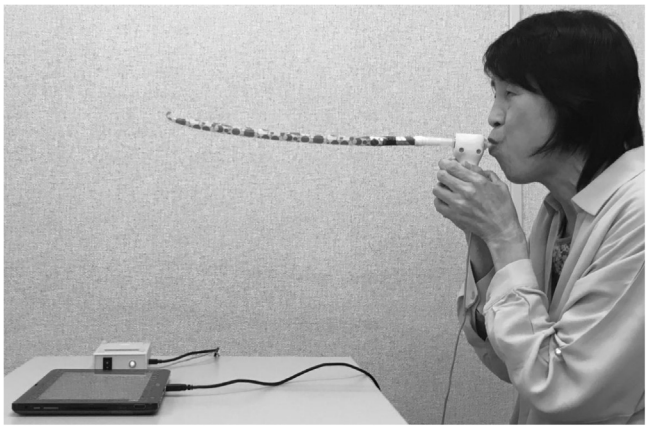

Fig. 1. Simple expiratory pressure measurement device.

After two practice trials, the participants performed the expiratory pressure test twice with a 3-min rest period between the tests.

For the spirometry test, participants held a disposable mouthpiece (Fukuda Denshi Co., Ltd., Tokyo, Japan) in the mouth and were instructed by the examiner to “breathe in” and “breathe out.” Two practice trials were performed before the vital capacity test. Respiratory disease patients did not participate in the practice trials, because they were already familiar with this test. As was done for the examination of expiratory pressure, the vital capacity test was performed twice with a 3-min rest period between the tests.

Both tests were conducted in the following order while the participants were comfortably seated: 1) first expiratory pressure test, 2) second expiratory pressure test, 3) first vital capacity test, 4) second vital capacity test.

2.3. Experimental procedure

We asked the Silver Human Resource Center to help us enroll healthy older people who fulfilled the following criteria: 1) no history of diagnosis or treatment of cardiopulmonary disease, 2) no diagnosis of dementia, and 3) able to perform light outdoor work in accordance with their age.

Healthy older people individually visited our university laboratory at an appointed time. After demonstrating the two types of testing methods, the subjects were asked to provide written informed consent to participate in the study. We then gathered data about sex, age, height, weight, type and frequency of light work, and any history of present illness before conducting the respiratory examination as described in the Apparatus section.

The respiratory disease patients were examined in accordance with the first periodic assessment conducted at the Respiratory Clinic. After the physical therapist demonstrated the two types of testing methods, the subjects were asked to provide written informed consent and the examination was performed in accordance with the methods described in the Apparatus section. In addition to the acquired data from the two tests, we gathered data concerning the participants' sex, age, height, weight, respiratory diagnosis, and oxygen flow rate during activity from the physical therapist. After the examination, participants were asked which device had simpler specifications.

2.4. Data analysis

Statistical analyses were performed with SPSS 22 (IBM Corp., Armonk, NY, USA). Of the two sets of spirometry measurements, we used the forced vital capacity (FVC), FEV_1, and peak expiratory flow (PEF) values from the test with the higher FVC value for the analysis.

The numerical data obtained from the measurement using the simple expiratory pressure measurement device are shown as a waveform in Fig. 2. Values for maximal expiratory pressure, integration expiratory pressure, and expiratory time used for the analysis were extracted from the waveform.

A Mann-Whitney test was used to compare the FVC, FEV_1, PEF, integration expiratory pressure, maximal expiratory pressure, and expiratory time values between the healthy older group and the respiratory disease group. Furthermore, the Spearman's rank correlation coefficient was used to evaluate the relationship between the FVC, FEV_1, and PEF values obtained by spirometry and the integration expiratory pressure, maximal expiratory pressure, and expiratory time values obtained using the simple expiratory

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