Effects of Inspiratory Muscle Training on Diaphragm Thickness, Pulmonary Function, and Chest Expansion in Chronic Stroke Patients

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Research Article

Abstract

Purpose: The purpose of this study was to investigate the effects of inspiratory muscle training on diaphragm thickness, pulmonary function, and chest expansion in chronic stroke patients.

Methods: The study participants consisted of 29 patients (17 males and 12 females) with chronic stroke who were divided into two groups: an inspiratory muscle training group (15 patients) and a control group (14 patients). All patients received general neurological rehabilitation for at least 6 months, and the inspiratory muscle training group was trained using a threshold inspiratory muscle trainer (IMT) device for 3 times per week, 20 minutes per session, for 6 weeks. Measurement of diaphragm thickness was performed using an ultrasound 7.5MHz linear probe before and during maximum inspiration (Tdi.con) and relaxation (Tdi.rel). Pulmonary function was measured using a pulmonary function meter, and chest expansion was measured using a goniometer.

Results: After 6 weeks of intervention, the inspiratory muscle training group showed a significant increase in diaphragm thickness and relaxation (p<.05). Forced expiratory volume in 1 second (FEV1) and peak expiratory flow (PEF) also showed a significant increase (p<.05), while forced vital capacity (FVC) and FEV1/FVC ratio did not show a significant increase (p>.05).

Conclusion: This study demonstrated that inspiratory muscle training can improve diaphragm thickness, pulmonary function, and chest expansion, thereby increasing the collaboration between respiratory muscles and reducing stiffness, which may be beneficial for future rehabilitation of chronic stroke patients.

Keywords: Inspiratory muscle training, stroke, diaphragm thickness, pulmonary function, chest expansion.
I. Introduction

A stroke is a major cause of social and physical dysfunctions, and it is reported that around 25 to 30 percent of stroke patients suffer from severe movement disorders (Duncan et al., 2002). Stroke patients have a poor cardiopulmonary function, given that a prolonged period of hospitalization and a bed-ridden living pattern deteriorates oxygen-transport ability and lowers their frequency of physical activity (Kashihara et al., 1994). In addition, the damage caused by a stroke to the motor cortex and the pyramidal tract leads to hemiplegia. As well, postural and muscle tonus and abnormal voluntary movement cause motor-control disorders and trunk-muscle synergy. This further damages coordination of respiratory-muscle contraction and deteriorates exercise capacity (De Almeida et al. 2011).

Stroke-induced hemiplegia injures the respiratory muscles of the paretic side and chest-wall mechanics (Annoni et al., 1990; Lanini et al., 2003). Previous studies reported that stroke patients suffered from a restrictive lung disease (Fugl-Meyer et al., 1983; Kim et al., 2011). Some 40 percent of stroke patients with restrictive ventilator impairment showed a decline in diaphragm displacement. Their forced vital capacity (FVC), forced expiratory volume in the first second (FEV1), and peak expiratory flow (PEF) were about half the level of healthy adults. As well, changes in oxygen saturation and respiratory pattern were observed in stroke patients’ arteries (Khedr et al., 2000). For this reason, stroke patients are more likely to feel fatigue in the inspiratory muscle and are at a greater risk of pulmonary complications (Larson et al., 1988; Loveridge et al., 1992).

Meanwhile, previous studies showed that a variety of exercises, such as muscular-strength exercises, independent pulmonary-muscle training, and aerobic exercise, effectively enhanced pulmonary function of stroke patients who were experiencing a movement disorder, deteriorated aerobic-exercise capacity, and cardiopulmonary function. Thus, to help stroke patients perform daily activities independently, it is important to enhance their pulmonary functions (Lee, 2008).

Inspiratory muscle training (IMT) is one such exercise: it applies a load to the diaphragm and to the accessory inspiratory muscles to improve the strength and endurance of these muscles (Moodie et al., 2011). IMT is known to enhance ventilator capacity of patients with inspiratory-muscle impairment regardless of whether the disorder is neurological or non-neurological (Petrovic et al., 2009). IMT is conducted in the same way to train skeletal muscles, based on the principles of overload, specificity, and reversibility.

Studies that compared healthy adults and those with a chronic obstructive pulmonary disease revealed that IMT enhanced the strength and endurance of inspiratory muscles (Gosselink et al., 2011; McConnell and Romer, 2004). Similarly, for patients with multiple sclerosis or Parkinson’s disease, it was shown that IMT effectively improved respiratory function, as well as the strength and endurance of the inspiratory muscles (Fry et al., 2007; Inzelberg et al. 2005). Only a few studies have been undertaken concerning IMT’s impact on the pulmonary function of chronic stroke patients with restrictive respiratory patterns. Therefore, this study applies IMT to chronic stroke patients over a period of six weeks and observes changes in their diaphragm thickness, pulmonary function, and chest expansion.

II. Methods

1. Participants

The experiment subjects were people who had been diagnosed with a stroke through computed tomography, had partial impairment in the cerebral hemisphere, and had a secondary injury of hemiplegia. The subjects had been with effects of a stroke for longer than six months and were undergoing general physical therapy, including