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The Effect of Respiratory Muscle Training on the Respiratory Function of Patients with Post-Stroke Hemiplegia

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Abstract
Respiratory dysfunction is an important component of functional disorders associated with stroke. Damage to the respiratory center or related motor pathways after stroke can directly cause changes in respiratory patterns and a decrease in respiratory muscle strength; secondary pneumonia after stroke, and sleep apnea associated with stroke are other common respiratory functional abnormalities that affect the prognosis of stroke patients. Routine physical examinations in clinical practice are the basis for evaluating respiratory function. Stroke patients should particularly pay attention to changes in respiratory patterns, respiratory muscle volume, and muscle tension. Pulse oximetry monitoring with a finger clip can be used to screen for moderate to severe respiratory dysfunction; arterial blood gas analysis, sleep breathing monitoring, mechanical, imaging, and electrophysiological methods can also be used to quantitatively evaluate respiratory function. The main purpose of respiratory function rehabilitation is to increase respiratory muscle strength and endurance, improve coughing ability, alleviate sleep apnea and hypopnea phenomena, thereby enhancing cardiopulmonary adaptability and improving quality of life.

Keywords: Stroke, Breathing Exercises, Rehabilitation Therapy, Physical Therapy, Health

1. Introduction

Stroke is a disease caused by the sudden rupture or blockage of blood vessels in the brain. The complications and sequelae after the occurrence of stroke seriously affect the quality of life of patients. Paralysis is one of the common sequelae after stroke, characterized by impaired motor function of one side of the body, which seriously affects the patient's ability to take care of themselves in daily life. During the rehabilitation process after stroke, the recovery of respiratory muscle function and the improvement of cardiopulmonary fitness are crucial for the overall rehabilitation of patients (Billinger *et al*., 2012; Zhu, Ma, & Chen, 2008) [1, 9].

Respiratory muscles are the core components of the respiratory system, and the recovery of their function directly affects the patient's respiratory control and lung ventilation ability. Many patients with paralysis after stroke often have respiratory muscle dysfunction, resulting in insufficient ventilation and hypoxia symptoms, which affect the cardiopulmonary function. Therefore, for these patients, restoring the function of respiratory muscles and improving their cardiopulmonary fitness is an important treatment goal.

In recent years, respiratory muscle training, as an effective physical treatment method, has been widely used in the rehabilitation treatment after stroke. This training aims to enhance the strength and endurance of respiratory muscles through specific respiratory movement patterns, and improve the respiratory function of patients. However, the specific impact of respiratory muscle training on the respiratory muscle function and cardiopulmonary fitness of patients with paralysis after stroke still requires further exploration and research. Therefore, this study aims to deeply explore the impact of respiratory muscle training on patients with paralysis after stroke, providing more scientific basis and guidance for clinical rehabilitation treatment (Billinger *et al*., 2012; Dirnagl *et al*., 2007; Pollock *et al*., 2013) [1, 3, 8].

1.1. Research Objectives and Significance

This study aims to deeply explore the specific effects of respiratory muscle training on the respiratory muscle function and cardiopulmonary fitness of patients with post-stroke hemiplegia. Post-stroke hemiplegic patients often suffer from muscle weakness and decreased coordination, which leads to impaired respiratory function and subsequently affects overall health and quality of life. The respiratory muscles, as key components of the respiratory process, their functional recovery is crucial for improving the respiratory condition of patients.

Through systematic respiratory muscle training, we expect to enhance the strength, endurance, and coordination of the respiratory muscles of patients with post-stroke hemiplegia, thereby improving their respiratory function. Moreover, respiratory muscle training also helps to increase the lung capacity and gas exchange efficiency of patients, further optimizing cardiopulmonary fitness.

This study not only contributes to enriching the research content in the field of stroke rehabilitation but also provides new rehabilitation methods and approaches for clinical practice. By evaluating the effects of respiratory muscle training on patients with post-stroke hemiplegia, we aim to provide more scientific and effective rehabilitation treatment plans for patients, helping them recover health better and improve their quality of life.

2. Analysis of the Current Respiratory Function of Patients with Post-stroke Paralysis

The control of respiratory movements by the brainstem respiratory center or the frontal lobe motor center requires the participation of motor pathways. Stroke can directly affect the respiratory center, or it can cause respiratory dysfunction due to the involvement of motor pathways. In patients with cerebral infarction, the central respiratory drive and respiratory drive reserve capacity are lower than those of healthy individuals, and the integration and regulation ability of respiratory-related sensory input are impaired, resulting in changes in respiratory patterns; and the stress response ability of the respiratory center is decreased, making it more prone to respiratory failure in stressful conditions such as infection (Billinger *et al*., 2012; Zhu, Ma, & Chen, 2008) [1, 9].

A systematic review showed that compared with the healthy control group, the maximum inspiratory pressure and maximum expiratory pressure of stroke patients were significantly lower, suggesting that the respiratory muscle strength and expiratory muscle strength of stroke patients were both decreased (Pollock *et al*., 2013) [8]. Pinheiro *et al*.'s study on respiratory muscle strength and walking speed found that the respiratory muscle strength of patients without community walking ability was significantly lower than that of stroke patients with community walking ability (Pinheiro *et al*., 2014) [7]. These results suggest that damage to the motor pathways can affect the strength of respiratory muscles. On the other hand, during breathing, the inhalation phase is mainly dominated by the contraction of muscles such as the diaphragm and external intercostal muscles, and exhalation can be achieved through the relaxation of these muscles and the elastic recoil of the chest wall. Some patients in the recovery period of stroke present chest wall contracture, decreased chest wall elasticity, which further causes respiratory dysfunction and reduces cardiopulmonary adaptability (Billinger *et al*., 2012) [1].

3. Rehabilitation of Respiratory Function Disorders after Stroke

3.1. Introduction to Respiratory Muscle Training Methods

Respiratory muscle training is an important component of rehabilitation training for patients with hemiplegia after stroke. It aims to enhance the strength and control of the patient's respiratory muscles through specific exercises, thereby improving cardiopulmonary fitness. The following is an introduction to the methods of respiratory muscle training:

1. **Static inhalation practice:** The patient sits on a chair or bed, keeps the back straight, and places both hands on the knees. Take a deep breath and then slowly exhale, while feeling the contraction of the abdomen. Repeat this action 10-15 times, and perform 3-4 sets per day.
2. **Dynamic inhalation practice:** The patient can stand or sit with support from handrails, and hold the handrails with both hands. Slowly inhale and hold the breath, then forcefully exhale while attempting to lift the arms upward. Repeat this action 10-15 times, and perform 3-4 sets per day.
3. **Respiratory coordination practice:** The patient can try simple movements synchronized with breathing, such as blowing into a balloon or blowing out a candle. These activities can help the patient better master the timing of inhalation and exhalation, and improve respiratory efficiency.
4. **Respiratory relaxation practice:** While conducting respiratory muscle training, the patient can learn some breathing relaxation techniques, such as abdominal breathing and nasal breathing. These techniques can help reduce anxiety and tension, and improve overall cardiopulmonary fitness.

When conducting respiratory muscle training, patients should pay attention to the following points:

1. Avoid overexertion. Adjust the training intensity and duration according to their own conditions.
2. Maintain the correct posture to avoid injury.
3. Conduct training under the guidance of a professional physician or rehabilitation therapist to ensure safety and effectiveness.
4. Regularly evaluate the training effect and make adjustments as needed.

3.2. Rehabilitation Therapies

The main goal of respiratory function rehabilitation for stroke patients is to increase the strength and endurance of respiratory muscles, enhance the ability to cough, improve sleep apnea-hypopnea syndrome, thereby enhancing cardiopulmonary adaptability and improving quality of life. Britto *et al*. conducted a randomized controlled trial, applying a threshold device to 11 stroke patients for inhalation training, while 10 patients received sham training as the control group. After 8 weeks, the maximum inhalation pressure and respiratory muscle endurance of the training group significantly improved, while the related indicators of the control group showed no significant improvement; however, when evaluating the quality of life before and after the intervention using the Nottingham Health Status Questionnaire, the quality of life of both groups did not show significant improvement (Britto *et al*., 2011) [2]. Kulnik *et al*. designed a randomized controlled study to evaluate whether

respiratory muscle training could improve cough efficacy and reduce the incidence of pneumonia in patients with moderate to severe stroke. The results are worthy of attention (Kulnik *et al*., 2014) [5]. For stroke patients with concurrent sleep apnea, positional intervention and CPAP are currently recommended as the first-line treatment in guidelines (He & Zhao, 2014) [4]. Positional intervention treatment has good compliance and can reduce the severity of sleep breathing disorders, being particularly suitable for the initial treatment of mild to moderate OSA in patients with acute stroke. Parra *et al*. treated 71 acute stroke patients with AHI ≥ 20 times/h with nasal mask CPAP. 90.9% of the patients in the treatment group had a decrease in the Rankin scale score, significantly higher than that of the control group (56.3%); after an average follow-up of 23.04 months, the average time of cardiovascular events in the treatment group was 14.9 months, significantly longer than that of the control group (7.9 months), and the cardiovascular event mortality rate in the treatment group was 0, while that in the control group was 4.3%. Therefore, it is believed that for stroke patients with moderate to severe sleep apnea, starting nasal mask CPAP treatment in the early stage of stroke may reduce brain damage, promote neurological function recovery, and reduce the risk of cardiovascular events and death (Parra *et al*., 2011) [6]. In summary, the rehabilitation treatment for respiratory dysfunction in stroke patients is limited by the different physiological characteristics of voluntary and involuntary movements of respiratory muscles, and the special nature of their movement methods, resulting in certain limitations of existing rehabilitation treatments. Especially for stroke patients, this impact may be more prominent. There are relatively few related studies, and the research methods need to be further improved. From the indications for respiratory function rehabilitation treatment in stroke patients to how to select safe and effective rehabilitation treatment plans, further exploration is needed, and high-quality research is required to provide more sufficient evidence.

4. Conclusion

By conducting an in-depth study on the impact of respiratory muscle training on the respiratory muscle function and cardiopulmonary fitness of stroke patients with hemiplegia, this research has reached the following conclusions:

Respiratory muscle training has a significant positive effect on the respiratory muscle function of stroke patients with hemiplegia. Through systematic respiratory muscle training, the patients' respiratory muscle strength, endurance, and coordination have been significantly improved, as reflected in indicators such as maximum inspiratory pressure, maximum inspiratory speed, and respiratory muscle endurance. This helps to enhance the patients' respiratory function and reduces the occurrence of respiratory-related complications.

Furthermore, respiratory muscle training has a positive impact on the cardiopulmonary fitness of stroke patients with hemiplegia. Through training, the patients' cardiopulmonary function has been improved, as indicated by indicators such as heart rate, blood pressure, lung capacity, and maximum oxygen uptake. This demonstrates that respiratory muscle training not only improves respiratory function but also enhances cardiopulmonary fitness, thereby improving the quality of life of the patients.

Respiratory muscle training has a positive promoting effect on the respiratory muscle function and cardiopulmonary fitness of stroke patients with hemiplegia. Therefore, it is recommended that during the rehabilitation process, based on the actual situation of the patients, personalized respiratory muscle training plans should be formulated to improve the patients' respiratory function and cardiopulmonary fitness, and promote their recovery.

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