GOAL-ORIENTED BREATHING EXERCISES IN ACUTE PERIOD AFTER STROKE

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ABSTRACT

The respiratory function of patients with stroke becomes worse and may lead to restrictive disorders in ventilation and pulmonary complications.

The purpose of this study is to establish the ability to influence respiratory disorders through a feedback breathing device in the acute period after a stroke.

The research was done among 59 patients who were monitored in the acute period after an ischemic stroke. They were divided into two groups, exercise group (EG) and control group (CG), according to their consent to perform breathing exercises at home. Forced vital capacity (FVC), peak expiratory flow (PEF), forced expiratory volume at 1 s (FEV1) and inspiratory capacity (IC) were measured.

There were significant differences in the first month in the PEF and IC between the two groups. All spirometric parameters improved in the EG with significant increase in FEV1 and IC.

The conducted study and the results indicate that goal-oriented training by incentive breathing device provides informative feedback on inspiration, facilitates cognitive stage, and positively influences inspiratory capacity among patients with acute ischemic stroke. The self-control during breathing facilitates early involvement of the basic principles of motor learning.

Keywords: *physical therapy, stroke, breathing exercises*

INTRODUCTION

Respiratory dysfunction following cerebrovascular diseases depends on size, process localization, and collateral circulation, and has various manifestations including disturbances of breathing. It is known that breathing can be controlled volitionally by corticospinal pathways or involuntarily on bulbospinal pathways. Cerebral cortex plays no significant role in calm breathing (Laniniet et al., 2003). The presence of respiratory muscle weakness was observed in many patients with stroke (Lanini et al., 2003; Sutbeyaz et al., 2010; Ward et al., 2010). Cerebral vascular maladjustments, including impaired motor control, may compromise the function and synergy of muscles involved in the respiratory cycle. The authors believe

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that the abnormalities are associated with a decrease in the strength of the respiratory muscles, a reduction in the mobility of the chest, a change in the posture of the body, and a negative impact on the efficiency of the cough mechanism. The weakness of respiratory muscles is related to the development of pulmonary infections (Smith et al., 2009) and leads to a restrictive disorder in ventilation, hypoventilation, and hypoxemia (Ward et al., 2010). Respiratory dysfunction may be a consequence of both respiratory muscle weakness and impaired motor control, associated with the inability to perform a number of functional motor activities, as the body muscles also participate in the control of respiratory movements (Howard et al., 2001).

METHODOLOGY AND METHODS

Purpose

To establish the ability to influence respiratory disorders through goal-oriented breathing exercises in the acute period after stroke.

Subjects

Fifty-nine patients (33 men and 26 women) of average age 71,1±6,2 years with light to moderate strokes (NIHSS scale 8,8±2,3 points, 18 to 20 points Glasgow-Liege scale), voluntarily attended, were included. All the patients had experienced ischemic stroke (computed tomography scan confirmed), and 31 presented with right sided paresis. All the patients were able to understand instructions, perform commands, and participate in physical therapy after the neurologist had determined that mobilization was indicated.

Outcome measures

On the day of hospital discharge and one month after a stroke, the following functional respiratory indicators were monitored - FVC, PEF and FEV1, using a portable spirometer (Vitalograph Micro Spirometer). Inspiratory capacity was measured with the device Coach2 Incentive Spirometer (in ml, rounded to the nearest 50 ml). Both studies were conducted in supine lying with raised upper part of the trunk from 30° to 45°. All pulmonary function measurements were taken after three attempts, the best achievement is reported.

Intervention

Individual feedback breathing device for inspiratory training (Coach2 Incentive Spirometer) was given (after instruction and training) to all patients. The instructions to patients were to apply goal-oriented breathing training from the day of discharge as a home-based training. In the hospital, the patients were educated to perform 5 inspirations in three positions – affected side lying, unaffected side lying and supine lying with raised upper body part with 1 to 3 minute rests between them, at least 3-4 times a day. In the course of the study we found out that only 44 of all patients performed breathing training at home. The rest of the patients declined to participate in inspiratory training. This gave us a reason to analyze the results of two groups: exercise group with inspiratory training and control group without breathing exercises. The baseline characteristics of the groups are presented in Table 1. All the patients performed physical therapy to achieve an optimal level of functional recovery according to the baseline status and the motor activity, previously described (Grigorova-Petrova et al., 2014; Grigorova-Petrova et al., 2014).

Table 1. *Baseline characteristics of two groups*

	EG	CG
Age	71,14±5,48	70,87±8,16
Gender male/female	24/20	9/6
NIHSS score	5,6±2,23	5,2±1,56
Paretic side left/right	18/26	10/5

EG – exercise group, CG – control group

RESULTS

The data obtained in this study was analyzed using SPSS version 19.0. To make comparisons between the pre- and post-test data for the 2 groups, Student's t-test for paired and unpaired sample was performed and a p-value less than 0.05 was considered to indicate a statistically significant difference. Patients' results of respiratory indicators are shown in Table 2.

Table 2. *Comparison of changes in pulmonary function before and after treatment*

Variable		Pre	Post
FVC (l)	**Exercise group**	2,11±0,66	2,07±0,63
	Control group	2,08±0,67	1,83±0,64*
	p	0,869	0,218
FEV1 (l/s)	**Exercise group**	1,35±0,53	1,45±0,54***
	Control group	1,58±0,43	1,27±0,51*
	p	0,129	0,284
PEF (ml/s)	**Exercise group**	183,04±71,90	187,59±54,74
	Control group	193,,66±52,17	154,30±45,95***
	p	0,601	**0,039**
IC (ml)	**Exercise group**	1567,82±595,32	1633,55±650,40*
	Control group	1559,70±623,42	1180,93±873,33***
	p	0,964	**0,020**

*FVC - forced vital capacity, PEF - peak expiratory flow, FEV1 - forced expiratory volume at 1 s, IC - inspiratory capacity, StudentT-test *** p<0.001, * p<0.05*

There were significant differences in the first month in the PEF and IC between the two groups. All spirometric parameters improved in the EG with significant increase in FEV1 and IC but significant decline of all dynamic indicators of the control group was observed.

DISCUSSION

Consequences of hemiparesis may include abnormalities in muscle tone and postural and motor control, which leads to inadequate functioning of the entire body and could compromise voluntary motor function. In the current study, we investigated the effects of breathing exercises using an individual respiratory device on the pulmonary function in stroke patients. The respiratory function of patients with stroke becomes worse and may lead to restrictive disorders in ventilation and pulmonary complications (Ward et al., 2010). Preventing complications should be a top priority at all levels of risk (Wilson, 2012). On the other hand, the improvement in pulmonary function is associated with a reduced risk of future complications with patients with stroke (Britto et al., 2011).

We hypothesized that performing breathing exercises by using a personal device, which allows goal-oriented training to increase the inspiration by visual feedback, could influence and improve pulmonary function.

The visual feedback allows the early application of principles of motor learning and stimulates and facilitates the active response (through trial and error), supported by other authors (Langhorne, 2011). The involvement of visual stimulation allows adjustment feedback during inhaling and leads to improvement of motor control of respiratory muscles. Thus, implementation is facilitated by the inclusion of implicit processes, enabling automation and possibly contributing to long-lasting changes (Pohl, 2006). Other authors (Kim, 2011; Sutbeyaz, 2010; Britto et al., 2011) also used a targeted workout with an incentive breathing device to improve the respiratory function in neurological disorders, and report an improvement in the spirometric data in stroke patients. Their studies were conducted in a subacute or chronic period with duration of 4 to 8 weeks. Our findings suggest that the incentive breathing device might be applicable in the acute period for improving pulmonary function.

Breathing could be activated volitionally through corticospinal pathways, or automatically through bulbospinal pathways. Deep breathing is under control of the corticospinal pathways and it is voluntary and depends on patient's ability or willingness to activate breathing. Dysfunction of inspiratory muscles may lead to decreased lung volume at the beginning of expiration (e.g., cough), and the weakness of the expiratory muscles leads to decreased intrathoracic pressure and inadequate airflow (Pollock, 2013). This may cause ineffective cough mechanism, which worsens the protection against aspiration and chest infection (Widdicombe, 2011). The inspiratory capacity data in this study showed significant improvement in the EG due to training and improved motor control of respiratory muscles. Breathing exercises with an individualized respiratory device may improve pulmonary function and cough effectiveness, and reduce risk of pneumonia.

The reduced muscle strength and impairments in motor control after stroke lead to walking difficulties (Vasileva et al., 2017) which, in combination with deteriorated pulmonary function, limits the activities of daily living and obstructs the full recovery of bodily functions. Stroke patients often fail to sustain the minimum fitness level required to maintain independent living and are inclined to sedentary lifestyle (Sutbeyazet al., 2010). This suggests that when a stroke becomes a chronic condition, a patient's lifestyle becomes more inactive, and pulmonary function continues to decline. This is confirmed by the results of CG one month later. On the other hand, the results obtained for the patients in EG confirmed the need of prolonged practice of breathing exercises in order to achieve long-lasting changes, as some other authors also reported (Dimitrova et al., 2016). Inspiration training could be an effective intervention method to facilitate increase in overall physical activity. However, we need to emphasize that due to the short period of observation, it was difficult to examine the long-term effects of respiratory training.

CONCLUSION

Goal-oriented training by incentive breathing device provides informative feedback on inspiration, facilitates cognitive stage, and positively influences inspiratory capacity in patients with acute ischemic stroke. The self-control during breathing facilitates early involvement of the basic principles of motor learning.

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