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Effect of PNF Approach to Scapular Adductor Muscles on Scapular Movements and Walking Ability in Patients with Stroke

This study investigated the effects of indirectly applying proprioceptive neuromuscular facilitation (PNF) to the scapular adductor muscles of stroke patients on their scapular movements and walking ability. Five patients who were diagnosed with stroke participated in this study as a single group. PNF patterns were applied to the scapulae anterior elevation and posterior depression patterns and upper limbs patterns of the patients in side lying and sitting positions together. The data were analyzed with a paired t-test in order to identify within-group differences in the measurements before and after the intervention. The scapular movements of the upper and lower parts, weight bearing and walking speed were significantly improved in the stroke patients after the application of PNF ($p<0.05$). These results suggest that PNF training effective in improving the scapular movements and walking ability in patients with stroke.

Key words: *Stroke; PNF; Scapular Movement; walking*

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INTRODUCTION

Stroke patients with hemiplegia fall more frequently and have increased risks of secondary damage due to abnormal walking, weakened muscular strength, and functional impairment [1]. Stroke is one of the main causes of disability in adults, and is commonly accompanied by the loss of motor skills [2]. Muscular weakness is a main factor that impedes motor skills; it plays a major role in inducing physical disability in stroke patients [3] and can be seen not only in paralyzed, but also in non-paralyzed sides [3, 4, 5].

The scapulae are frequently retracted due to hypertonicity; Paine and Voight [6] argued that the muscles around the scapulae should be aligned for shoulder joint stability and the dynamic positioning of the muscles plays a critical role in moving the glenohumeral joints. Ellenbecker et al [7] reported that the movement of one segment affected other proximal and distal parts. Several factors, such as muscular weakness and hypertonicity, have been known to restrict the functions of the limbs. Lai et al [8] reported that 55 to 80% of stroke patients with impaired upper limb functions even after six months of recovery after injury had permanent dysfunction in the performance of daily living activities. Kelly et al [9] reported that stroke patients walked more slowly, with more energy consumed, and for a shorter duration when compared to normal people.

During normal walking, the opposite pelvis moves with 4° of descent, 4° of forward slope, and 10° of horizontal rotation. When one foot touches the ground, the lower limb is located in front of the body and the upper trunk is aligned and adjusted on the lower trunk. As the torso moves forward, the hip joint is extended from the previous flexed posture to a neutral posture. One of the elements necessary for improvement in the hip joint extension is the alignment and control of the trunk and the upper limbs. Instability or damage due to trunk paralysis may induce inappropriate patterns, which reduce the quality of walking [10].

Walking is closely associated with trunk rotation, during which thoracic and pelvic rotation coordination is significant [11]. The thoracic vertebrae, in particular, are connected to various muscles, such as the large and small rhomboid muscles and the trapezius middle fibers, and are involved in not only the stability of the scapulae, but also the movement of the upper limbs. The large and small rhomboid muscles, the trapezius middle fibers, and the levator scapulae pull the angulus inferior scapulae superomedially and lift the scapulae to induce the glenoid fossae to face downward. As for upper extremity motility, 1° of supraduction occurs in the scapulothoracic joints when the glenohumeral joints are abducted by 2° or flexed. In both flexion and abduction, the movement of the glenohumeral joints for the movement of the scapulothoracic joints is at a ratio of 2:1 [12].

Wang [13] reported that studies on the effectiveness of PNF-based treatment have been both supportive and conflicting and that very few studies on pelvic facilitation for gait improvement existed. Although there have been many studies using proprioceptive neuromuscular facilitation (PNF) for stroke, sports injuries, and musculoskeletal disorders, little research has been done on the effects of the intervention on the scapular movements and walking of stroke patients when it is applied to their scapular adductors. In this context, this study attempted to identify the effects of training using PNF on the scapular adductors of stroke patients.

METHODS

Subjects and Methods

The subjects were five patients who were admitted to a hospital in Seoul from 2 .Jan, 2017 to 10 Feb, 2017; Subjects were screened according to the following inclusion and exclusion criteria. The inclusion criteria for this study were categorized as [1] they were diagnosed as having hemiplegia caused by stroke that had occurred at least six months before, [2] were classified as grade 4 or higher in the Brunnstrom stages of recovery for hemiplegic patients, and [3] had convulsions in their scapular adductors. [4] The five subjects had 24 points or more in the Mini-Mental State Examination-Korean Version (MMSE-K), [5] were able to walk more than 10 meters independently. And exclusion criteria for the study were [1] had cardiovascular patients [2], medical, or orthopedic disorders that could affect treatment. They performed a treatment program consisting of 30-minute sessions five times per week for six weeks.

General characteristics of the subjects

There were four men and one woman in the study group. The participants' mean age was 49.80 ± 12.91 years, mean body weight was 72.40 ± 17.96 kg, and mean height was 173.00 ± 9.69 cm(Table 1).

Table 1. General characteristics of subjects (n=10)

Characteristics		Mean±SD
Sex	Male	4
	Female	1
Affected side	Right	3
	Left	2
Type of Injury	Infarction	2
	Hemorrhage	3
Age		49.80 ± 12.91
Weight		72.40 ± 17.96
Height		173.00 ± 9.69

Intervention

We fully explained the purpose and methods of this study to the subjects, and asked them to restrict unnecessary actions that could affect the research.

PNF was developed by Dr. Herman Kabat in the 1940s. It is a therapeutic exercise method that identifies mass movement on a neurophysiological basis, such as reciprocal innervation and the control and progress of irradiation proposed by Sherrington, and that are characterized by spiral and diagonal patterns.

While a subject was in a side lying position or in a sitting position based on what he or she could do, the movements of their scapulae were activated by using anterior elevation and posterior depression patterns of the bones. Furthermore, the flexion-adduction-external and the extension-abduction-internal rotation patterns of the upper limbs to which the movements of the scapulae and the upper limbs were connected were done by turns in order to activate the movements of the bones and the limbs. Then, a combination of isotonic contraction and a technique of dynamic reversal were applied to induce free movements of each pattern.

Measurement tools

We used a tape measure to identify the location of the scapulae. We modified and supplemented the methods used by Odom et all [4] and Toshiaki and Yoshio [15] for this study. We measured the distance from the spinous process of the second vertebra to the superior angle of the scapula and the distance from the spinous process of the seventh vertebra to the inferior angle of the scapula when the subject was in a comfortable sitting position, in order to identify differences. To investigate walking ability, we measured the pressure on the fore and heel of the foot by using a sensor attached to the insole. A portable compact control unit attached to the ankle temporarily saved the patient's walking data, which was wirelessly sent to a computer on which Smart Step was installed and evaluated the walking ability.

Data analysis

The collected data were statistically processed by using the Windows SPSS Version 18.0 statistical program. To identify within-group differences between pre- and post-intervention, a paired t-test was used. The statistical significance level was set at .05.

RESULTS

1. Changes in scapular movements

There was a statistically significant difference ($p < 0.05$) in the distances between the spinous process of the second vertebra and the superior angle of the scapula and those between the spinous process of the seventh vertebra and the inferior angle of the scapula.

Table 2. TChange of scapula motion

(cm)

	Position	Pre	Post	p
Change of scapula motion	Upper	7.40 ± 1.88	6.40 ± 1.55	.039*
	Lower	12.00 ± 3.48	13.10 ± 3.38	.041*

〈Upper : Distance of T2 to superior angle of scapula, Lower : Distance of T7 to inferior angle of scapula〉*p〈.05

2. Changes in walking ability

Weight bearing and speed while walking, which were measured to identify changes in walking ability between pre- and post-intervention, showed statistically significant changes ($p < 0.05$).

Table 3. Change of walking ability

(kg, sec)

	Pre	Post	p
Weight bearing	60.28 ± 10.28	64.06 ± 9.93	.038*
Walking speed	32.37 ± 7.07	35.18 ± 7.05	.017*

*〈.05

DISCUSSION

Stroke usually results in an impaired life with disability; neurological symptoms after cerebral artery injury may induce damage to one cerebral hemisphere and to the contralateral body and limbs [16]. The primary purpose of physiotherapeutic intervention is functional recovery. When examining a body after injury, many symptoms are observed, including muscle weakness resulting in the loss of hand functionality, reduction in sensory-motor functions, hypertonicity, and reduction of coordination [5].

Smooth movements of the glenohumeral joints for the movements of the scapulothoracic joints are needed to move the upper extremities comfortably. Movements of the glenohumeral joints have been reported to be connected to trunk rotation and movements of the scapula4, [17]. Similarly, in this study, we observed that PNF was effective for improving the movements of the scapula.

Pontzer et al. [18] reported that moving the upper limbs while walking affected the movements of the pelvis and the shoulder joints with close association, while Choi Jin Ho et al.[19] reported that PNF exercise of the affected pelvis and the lower limbs could increase the walking ability and speed of hemiplegic patients. Choi Jin Ho et al. [19] also identified increases in the strides of the affected lower limb.

In this study, although the patients did not undergo exercise applied directly to the affected lower limbs, the PNF applied to their scapular adductors, muscles that are closely related to the limbs, led to improvements in weight loading and walking speed. These results are consistent with those of Pontzer et al [18] and Choi JH et al [19], demonstrating that scapular movements and upper limb functions are intimately associated with walking.

The results of this study show that PNF may improve the movement of the scapulae and walking when it is applied to the scapular adductors of stroke patients. Further studies may be needed to identify the effects of more diversified patterns and techniques.

CONCLUSIONS

In this study, we applied PNF to the scapular adductors in order to identify its effects on the scapular movements of the affected side and walking of stroke patients. Statistically significant changes were observed in the scapular movements ($p < .05$). In terms of walking, weight loading changed significantly ($p < .05$) and speed increased significantly ($p < .05$). As clinical research on the effects of PNF on changes in the scapular movements, weight loading, and walking of stroke patients, this study provides important data for treating such patients. Further studies on more patients may be needed to generalize the results of this study.

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