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Effects of Combination Patterns of Proprioceptive Neuromuscular Facilitation on Cervical Alignment, Self-Awareness and Physique in Patients with Forward Head Posture

The purpose of this study was to identify the effects of cervical alignment, pain, and physique to apply proprioceptive neuromuscular facilitation(PNF) techniques in patients with forward head posture (FHP). The subjects of this study were 24 patients diagnosed with FHP. They were randomly divided into two groups: a PNF group(n=12) and a control group(n=12). The intervention was performed a total of 24 times, 30 min a day, six times a week for four weeks. Data on cervical alignment(forward head displacement, FHD), pain(visual analog scale, VAS), and physique(height, weight, and body mass index) were obtained pre- and post-intervention. Two-way repeated measures ANOVA was used to compare the groups and time. For FHD, the VAS, and physique(height and BMI), there was an interaction effect for the groups and time($p<.001$, BMI: $p<.05$) and main effects for time($p<.001$, BMI: $p<.05$). For weight, there were main effects of time($p<.01$). For FHD($p<.01$) and the VAS($p<.05$), there were main effects for the groups. In the PNF group, there were significant improvements in FHD, VAS, and physique. In the control group, there was a significant increase in FHD. The results of this study indicated that PNF intervention using scapular and upper extremity patterns effective in FHP positively. The use of a therapeutic intervention on physique changes may also be effective in improving poor posture and help to better patients' quality of life.

Key words: *Forward Head Posture, PNF, Cervical alignment, Pain, physique*

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INTRODUCTION

Lookism, which determines individual merits and success in life, is rampant in our society, as looks are increasingly being emphasized. However, it is difficult to maintain good posture in today's information society contrary to people's desire to pursue an ideal posture to express their external beauty. Most office workers spend a considerable amount of time working. Working in poor posture leads to an imbalance in spinal alignment. In particular, the long-term use of visual display terminals (VDTs), such as computers and Smartphones, causes musculoskeletal disorders. Typically, workers have more forward flexion of the neck when they are working than during their leisure time(1). The ideal posture of the human body is defined as a balanced state of the musculoskeletal system in which the least amount of stress and pressure is applied(2); forward head posture (FHP) is a state in which the mid-position of the head comes out of its original position from the sagittal plane. It is often recognized as one type of posture deformation(3); in general, it is classified as forward head displacement (FHD) if it is more than 15 mm (4).

If negative changes in vertebral alignment are present, such as FHP, musculoskeletal disorders occur, such as upper crossed syndrome, and spinal imbalances due to cervical lordosis decrease, shoulder elevation and protraction, and thoracic kyphosis(5). In addition, FHP appears predominantly when people work on VDTs. These cause cervical and shoulder pain due to the increased weight bearing in cervical joints and soft tissue(6). Lee et al.(7) reported that VDT use time and the flexion of the neck and trunk were correlated, and poor posture due to the use of a VDT is thought to be a typical cause for pain and the abnormal arrangement of the spine, such as FHP. Thus, effort is required to increase quality of life and improving business efficiency and promoting by the recovery of ideal posture and normal spinal alignment, and decrease of pain before onset.

Proprioceptive neuromuscular facilitation (PNF) has been proven as a therapeutic intervention to help patients recover from central nerve system injuries as well as musculoskeletal disorders in clinical settings(8-11). In addition, irradiation through resistance, one of facilitation principles used in PNF, is the method used to facilitate exercise activity of weak or damaged areas by applying resistance to strong part of body(12). Cervical pain has been reported to improve due to the application of indirect PNF patterns to the upper extremity(9). However, studies applying PNF to improve of the functioning of patients with FHP are limited(9). Patients with FHP experience spinal problems including the upper and lower back and pelvic area as well as the neck . Although FHP reduces the height of the spine(14,15) and causes changes in individuals' overall appearance, aspects of physique such as height have not yet received attention.

The aim of this study was to identify the effects on cervical alignment, pain, and physique resulting from the application of scapular and upper extremity patterns of PNF via active exercise to improve proprioception in patients with FHP.

SUBJECTS AND METHODS

Subjects

The subjects of this study were 24 white-collar workers who had FHD of more than 15 mm(4) and cervical pain. Subjects were excluded who had problems with the application of the PNF technique by a specialist, special diseases, and a history of spinal surgery, and who did not have voluntary agreement. Initially, 30 subjects were randomly assigned to one of two groups: the PNF group (n=15) and the control group (n=15), respectively. Six subjects, three subjects from each group, were eliminated in the course of the study. The subjects voluntarily participated after being provided with the experimental details and giving written informed consent before the experiment. This study was approved by the Institutional Review Board of University (NSU-160331-2). The general characteristics of the subjects are shown in Table 1.

Table 1. General characteristics of the subjects (n=24)

Characteristics	PNF (n=12)	Control group (n=12)	p
Sex(M/F)	8/4	8/4	
Age(yrs.)	33.4±6.5	32.9±7.2	.860
Height(cm)	165.7±7.2	166.1±6.5	.892
Weight(kg)	64.1±15.5	64.7±9.6	.917
BMI(kg/m2)	23.2±4.4	23.4±2.6	.901
FHD(mm)	17.8±2.5	18.2±3.3	.722

Mean±Standard deviation
BMI: body mass index; FHD: forward head displacement; M: male; F: female

Data collection

A digital diagnostic X-ray imaging system (Distal X-ray TITAN 2000, GEMSS Inc., Korea) was used to measure the cervical spine of the subjects. A visual analog scale (VAS) was used to measure cervical pain by self-awareness. Subjects' physique was measured by their height, weight, and body mass index (BMI).

X-rays were taken in the Department of Radiology in the hospital at Y-si, K-do to evaluate the alignment of the cervical spine. The lateral view of the cervical spine was obtained in a state in which they looked forward in a standing position while relaxing the muscles of the upper extremity(16). X-rays were taken by the same radiologist. FHD was calculated based on the X-ray image. FHD was measured as the horizontal distance in mm from the posterior superior end of the C2 body to the posterior inferior end of the C7 body(4). Changes in cervical spine alignment were observed pre-intervention and four weeks later. The VAS has very high test-retest reliability (ICC=0.97)(17). The scale ranges from no pain '0' to severe pain '10', and subjects rated their own perceptions of their pain level(18). Height and weight were measured using Lohman et al.'s method(19), and subjects' BMI was calculated using the formula of weight/height2. All measurements were carried out 24 hours pre-intervention and 24 hours after the end of the four-week intervention. Errors were minimized by measuring at the same specified time.

Procedure

The experiment was conducted for four weeks. The PNF group performed the intervention for 30 minutes a day, six times a week, a total of 24 times. The control group was ensured that they would be provided with same intervention conducted in the PNF group after the experiment and was controlled the intervention during the study. The PNF group performed the scapular pattern in a side-lying position and the upper extremity pattern in a supine position. The upper extremity pattern was applied using symmetrical and symmetrical-reciprocal patterns. The sights of the subjects were stared at the end of hand and induced that neck moved along the end of hand. Rhythmic initiation (RI) and combination isotonic (CI) techniques were selected for education on accurate movement and patterns and to improve coordination, kinesthetic, and muscle strength(12). The intensity of the intervention was set to 11-12 based on subjects' rating of perceived exertion (RPE). The intervention program is shown in Table 2.

Statistical analysis

The data of this study were analyzed using the statistical program SPSS 21.0. The descriptive statistics were expressed as mean ± standard deviation(SD). Two-way repeated measures ANOVA was used to compare the mean differences between the two groups(PNF group and control group) and times(pre- and post-test). When there were interaction and main effects for the group and time, an independent t-test was used to compare the mean differences between the groups at the same time; a dependent t-test was used to compare the mean differences between the times in the same group. The statistical significant level was set to $\alpha=0.05$.

Table 2. Scapular & combination patterns of PNF

Phases	Positions	Treatment	Time	Notes
Warm-up	Supine	Manual traction, ROM exercise	5 min	
Main exercise	Side-lying	1. Scapular pattern Rt. (Lt.) Scapular anterior elevation & posterior depression, posterior elevation & anterior depression	20 min	1 week RI 1 sets of 10 reps.
	Supine	2. Upper extremity pattern 2.1. Symmetrical pattern Both shoulder flexion-abduction-external rotation & extension-adduction-internal rotation		2 weeks CI 2 sets of 10 reps.
		2.2. Symmetrical-reciprocal pattern Rt. (Lt.) shoulder flexion-abduction-external rotation with Lt. (Rt.) shoulder extension-adduction-internal rotation		3-4 weeks CI 3 sets of 10 reps.
Cool-down	Supine	Manual traction, ROM exercise	5 min	

Rt.: right; Lt.: left; RI: rhythmic initiation; CI: combination of isotonic; reps: repetitions

RESULTS

The FHD, VAS, height, weight, and BMI results are shown in Table 3. There were interaction effects for FHD with groups and time($p<.001$), VAS ($p<.001$), height($p<.001$), and BMI($p<.05$). There were main effects for time with FHD ($p<.001$), VAS ($p<.001$), height($p<.001$), weight($p<001$), and BMI ($p<.05$). There were main effects for the groups with FHD($p<.01$) and VAS ($p<.05$).

In the PNF group, there were significant improvements in all measured data. In the control group, there was a significant increase in FHD. There were no significant differences in all measured data with FHD.

DISCUSSION

The purpose of this study was to identify the effects of PNF patterns on FHD, VAS, and physique in patients with FHP. FHP, a state in which an individual's head was moved excessive forward in sagittal plane because of cervical malalignment, negatively affects the spine as well as one's appearance. If people continue to perform VDT work with neck flexion, such as FHD, the muscle tension around the cervical spine increases, eventually leading to pain(30). The degree of cervical flexion is more pronounced in those with cervical pain, which could be explained by the change in their motor control capability of the cervical muscles due to pain(31).

FHD is a representative index for evaluating the alignment of the cervical spine(ICC>0.7). CLA using the posterior tangent method has more an advantage in a standard error of measurement than Cobb's method using four straight lines(20). In this study, there was a significant decrease in FHD in the PNF group, which was recovered to the normal range; 15 mm inside as classification of the FHP(4). However, there was a significant increase in FHD in the control group. McAviney et al.(21) reported an average FHD of 21.3 mm in the cervical pain group and identified a static correlation between FHD and cervical pain. Person and Walmsley(22) evaluated a neutral resting posture applying neck retraction exercises to healthy adults with no pain. They found that the distance

Table 3. Changes in clinical outcomes post-PNF therapy

items	Group	Pre-test	Post-test	Δ%	p	
FHD (mm)	PNF	17.81±2.53	13.25±2.44	-0.81	Group	$.023^{+}$
	Control	18.24±3.31	18.67±3.52#	0.08	Time Group*Time	$.000^{+++}$ $.000^{+++}$
VAS (cm)	PNF	4.81±1.32	0.88±0.71	0.19	Group	$.001^{++}$
	Control	4.62±1.48	4.73±1.14#	0.01	Time Group*Time	$.000^{+++}$ $.000^{+++}$
Height (cm)	PNF	165.71±7.17	167.14±7.29	2.38	Group	.881
	Control	166.09±6.54	165.91±6.54	-0.30	Time Group*Time	$.000^{+++}$ $.000^{+++}$
Weight (kg)	PNF	64.12±15.52	62.80±14.16	-0.84	Group	.823
	Control	64.68±9.60	64.53±9.24	-0.09	Time Group*Time	$.026^{+}$ .068
BMI (kg/m2)	PNF	23.19±4.42	22.33±3.81	0.20	Group	.661
	Control	23.38±2.61	23.38±2.47	0.00	Time Group*Time	$.002^{++}$ $.002^{++}$

Mean±Standard deviation *$p<.05$; ** $p<.01$; *** $p<.001$
FHD: forward head displacement; VAS: visual analog scale; BMI: body mass index
*significant difference from the pre-test.; +significant main effect and/or interaction; #significant difference between groups in time

between the spine and tragus of the ears was significantly decreased, suggesting that FHD improved as a result of applying active exercise. Harrison et al.(23) divided 95 people into three groups: a cervical traction and chiropractic group, a chiropractic group, and a control group and applied exercises five times a week for 12 weeks. They reported a significant difference in FHD in the cervical traction and chiropractic group. Their results are consistent with this study applying an exercise intervention.

VAS values closer to 0 indicate no pain, and a significant difference was shown in the PNF group, representing improvement in the degree closed to '0' (0.88 cm), but no significant difference was shown in the control group. Lee et al.(24) studied the application of the sprinter and skater pattern of PNF four times a week for six weeks on patients with low back pain. There was a significant decrease in the VAS in the group who received this PNF combination pattern compared to the group who received ball exercises; the PNF combination pattern group was more effective than the ball exercise group. The study tended to match this study in that the effects of applying PNF on the upper or lower extremity positively affected on the trunk and the spine. The combination pattern of PNF is less of a burden because exercise is possible in conditions that did not cause pain through indirect application instead of direct stimulation and would help to relieve pain by improving individuals' proprioception control ability and sensory-motor function 9-24). In addition, Oh et al.(9) reported a significant improvement in the VAS as a result of applying symmetrical and symmetrical-reciprocal patterns on patients with FHP, consistent with this study. The study reported that patients' pain was reduced because the exercise using the PNF induced muscle voluntary contraction on the basis of active resistance exercise and led to the cross-training effect, improving the stability of the cervical spine, thoracic spine, and upper trunk as well as proprioception, and isometric muscle strength. The most studies was to identify the correlation between pain, muscle strength, and muscle endurance(25-27) and it thought that improved cervical muscle strength and endurance would be accompanied through active exercise, such as PNF, to resolve cervical defects.

When the subjects of this study measured height and weight to evaluating physique, most of them appealed that the height was slightly smaller than before. Because the abnormal curvature of the spine changes spinal height and affects overall height(14), the abnormal alignment of the spine in patients with FHP is sufficient to cause physique changes. In this study, there were significant improvements in the height, weight, and BMI in the PNF group, and no significant difference was shown in the control group. Stokes(14) identified a correlation between a reduction in Cobb's angle and spinal height through a regression analysis comparing Cobb's angle, spinal length, and spinal height on 407 patients with scoliosis aged 9-20. The author reported that the abnormal curvature of the frontal plane directly affected spinal height, regardless of the changes in intervertebral discs. Ylikoski(15) reported that spinal height decreased by 15 mm when there was 50° of kyphosis and identified a correlation between changes in the spinal curve on the sagittal plane and spinal height. This correlation is also thought to be related to the height reduction of patients with FHP. Thus, significant increases in the heights of the subjects were thought to be the quantitative recovery of the height because of pain relief and improved spinal alignment. When the BMI exceeds 24 kg/m2 or the waist hip ratio (WHR) exceeds 0.85, it negatively affects patients' general spinal alignment; the more obese one is, the greater the change in the lumbar lordosis angle, causing spinal pain(28). Schuller et al.(29) reported that the BMI of patients with simple low back pain was 24.8 kg/m2, of patients with low back pain and spondylolisthesis was 28.2 kg/m2 and the BMI was greater than 25.9 kg/m2 in 71.4% of the patients. They reported that spinal alignment problems such as spondylolisthesis had a static correlation with the weight and BMI than height was relatively shorter for those with lower back pain with spondylolisthesis. In this study, subjects' average BMI was 23.3 kg/m2, and there was a significant decrease in the PNF group from 23.2 to 22.3 kg/m2 as a result of four weeks of exercise. Accordingly, the VAS also significantly decreased from 4.81 to 0.88 cm and could confirm the correlation between patients' BMI and pain. Patients' spinal volume and height varied according to their height and weight; spinal volume is highly correlated with weight in males and with height in females, and spinal body height is highly correlated with height in males and females(33). Changes in the height, weight, and BMI of patients with FHD thus seem to be highly correlated with spinal alignment.

Because unstable posture of the head and neck can lead to cervical pain and the ability to maintain a neutral neck posture declines more and more as a result of VDT work in patients with cervical pain, maintaining proper posture becomes difficult(32). Silva et al.(34) reported that patients with cervical pain tended to maintain FHP as their pain intensity increased and identified a correlation between pain and poor posture. Poor posture changes the normal spinal curve and negatively affects physique changes, such as height, weight, and BMI. However, the scapular and combination pattern of the PNF applied in this study was not directed to treat the cervical spine; active exercise in functional movement improves stability and the muscle strength of the trunk as well as proprioception through the application of the scapular and combination pattern. It is thought cross-training effect was more shown in the cervical and trunk because especially the combination of isotonic technique applied to pattern improved isometric exercise ability of shoulder joint and produce irradiation effect. This change is thought to have a positive effect on cervical alignment, pain, and physique elements.

CONCLUSIONS

This study suggested the possibility of an indirect intervention applied to the scapular region and upper extremity on patients with FHP positively impacting their cervical alignment, cervical pain, and physique. The abnormal curvature of the spine changes spinal height and affects both standing height and sitting height, as previously stated(14). This study is significant in that it aimed to identify a new relationship between FHP and individuals' physique at the present time that was not noted the study to identify the physique changes and the relationship between the spinal malalignment and physique. Future research could attempt to identify the relationship between the direct and indirect various therapeutic interventions and physique elements, such as height, to resolve problems related to spinal alignment in the sagittal plane, such as FHP.

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