The Effects of Indirect Treatment of Proprioceptive Neuromuscular Facilitation

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Abstract. [Purpose] The purpose of this research was to clarify the effects of indirect treatment of proprioceptive neuromuscular facilitation (PNF). [Subjects] The subjects were thirty healthy male volunteers. Their mean age was 21.1 ± 1.1 years. [Methods] This study examined the extension force of the contralateral lower limb when manual isometric resistance exercise was performed by an upper limb at the start, middle, and final positions of PNF and shoulder flexion. A hand-held dynamometer measured the extension force of the contralateral lower limb. [Results] The extension force of the contralateral lower limb increased when an isometric resistance exercise was performed by an upper limb at the final position of the flexion-abduction-external rotation pattern of PNF. [Discussion] The extension force of the contralateral lower limb increased more with PNF movement than in shoulder flexion of an upper limb. The result suggests that isometric resistance exercise by an upper limb at the final position of PNF emphasized the “continue movement” and the systemic balance reaction occurred toward the side of the contralateral lower limb. This finding, therefore, could be applied to the treatment of patients having difficulty with moving their own lower limbs.

Key words: PNF, Indirect treatment, Isometric resistance exercises

INTRODUCTION

Proprioceptive neuromuscular facilitation (PNF) is used in therapeutic exercise. In Japan, many physical therapist students have learned PNF1). The characteristics of PNF include diagonal and spiral movements. It consists of direct treatment and indirect treatment. Indirect treatment uses the PNF pattern of muscle contractions of upper limbs to lower limbs (irradiation)2). Previous studies of indirect treatment have reported that PNF for a lower limb increased muscle contractions in the contralateral lower limb3) and that PNF for the scapula or pelvis increased ankle or shoulder range of motion4,5). These studies, however, did not report on the degree of influence of an upper limb on the contralateral lower limb.

We reported the effect of indirect treatment of PNF6–8). The purpose of this study was to investigate the effect of indirect treatment of PNF. This study examined the extension force of the contralateral lower limb when manual isometric resistance exercise was performed by an upper limb at the start, middle, and final positions of the flexion-abduction-external rotation pattern of PNF.

SUBJECTS AND METHODS

Subjects

The subjects were thirty healthy male volunteers
without history of orthopedic or neurological diseases in all limbs. Their mean ± standard deviation (SD) age was 21.1 ± 1.1 years, their mean height was 170.5 ± 4.8 cm, and their mean weight was 63.4 ± 7.3 kg. Prior to participation in this study, informed consent was obtained from all the subjects. The subjects chosen for this investigation were intelligent and cooperative volunteers, who were fully informed about the nature and the purpose of this study, an essential prerequisite for obtaining accurate information.

Methods

The subjects adopted a supine position from head to hip on a hard table, and their feet were placed shoulder-width apart with the lower limbs extended on another hard table. We used three hand-held dynamometers (HHD; µ-TAS MF-01; ANIMA Co, Japan) set up in manual mode with units of kgf. The measurement time was 10 seconds. HHD were reset to 0 kgf at the start of every measurement.

Two HHD were attached to the subject’s heels in the supine position, and maximum voluntary isometric contractions (MVIC) of the extension forces of the lower limbs were measured. The extension forces of the lower limbs were also measured with two HHD while an isometric resistance exercise was performed by an upper limb. All subjects performed both PNF movement and shoulder flexion movement of an upper limb. The PNF movement used was the flexion-abduction-external rotation pattern. In both movements of the upper limb, isometric resistance exercises were performed at each of the 3 upper limb positions. The elbow, wrist and fingers of the upper limb were extended, and the middle position was assumed to be the same as a shoulder flexion angle of 90 degrees. The isometric resistance exercise was performed for 3 or 4 seconds each time in each of the positions with a physical therapist applying manual resistance. The forces of the isometric resistance exercises were modulated so that the subject’s upper limb did not move due to the manual resistance applied by the physical therapist. Simultaneously, the force of the upper limb in each position was measured with a HHD placed on the subject’s wrist joint (Fig. 1). The testing positions of the upper limb were randomly selected with cards. All force assessments were performed by the same physical therapist, an instructor certified by the PNF society of Japan.

Later, we examined the intra-rater reliability with fifteen people selected from the subjects of this study at random.

Statistical analysis was performed with SPSS 15.0 software package for Windows. The level of statistical significance was set at 0.05. Descriptive statistical methods were used for calculating means and SD. Two-way analysis of variance (ANOVA) followed by Tukey post hoc comparisons were used to analyze the differences of the extension forces of the contralateral and ipsilateral lower limbs while performing isometric resistance exercises in each of the upper limb positions (start, middle, and final), in PNF and shoulder flexion movements. In addition, paired t-tests were used to examine the differences between PNF and shoulder flexion in each upper limb position. The intra-rater reliability of the force of the upper limb in the final position of PNF movement and the extension force of the
contralateral lower limb were analyzed using intraclass correlation coefficient (ICC; version 1, 1).

**RESULTS**

The means of MVIC of the extension forces of the contralateral and ipsilateral lower limbs were 17.1 ± 2.9 kgf, and 17.4 ± 3.1 kgf, respectively. MVIC of both lower limbs were not significantly different. The extension forces of the lower limbs when isometric resistance exercises were performed by an upper limb are shown in Table 1. In both movements, the extension forces of the lower limbs increased. The force of the contralateral lower limb increased more than that of the ipsilateral lower limb during isometric resistance exercise of an upper limb and both were significantly increased at the final position of PNF and shoulder flexion movements. The extension forces of the contralateral lower limb increased significantly more PNF movement than in shoulder flexion movement at each of the upper limb positions, (Table 2). The means of %MVIC of the extension forces of the lower limbs when isometric resistance exercises were performed by an upper limb are shown in Table 3.
In addition, the forces of isometric resistance exercises of an upper limb at the start, middle, and final position of PNF movement were 11.2 ± 2.1 kgf, 9.8 ± 2.1 kgf, and 9.1 ± 1.8 kgf, respectively. In shoulder flexion movement, the forces of isometric resistance exercises of an upper limb at the start, middle, and final position were 11.8 ± 2.7 kgf, 10.4 ± 1.9 kgf, and 9.1 ± 2.0 kgf, respectively.

The ICC of the force of an upper limb at the final position of PNF movement was 0.836; the ICC of the extension forces of the contralateral lower limb was 0.845. These intra-rater reliabilities were good.

**DISCUSSION**

The extension force of the contralateral lower limb was increased significantly when isometric resistance exercise was performed by an upper limb at the final position of PNF movement. This result indicates that isometric resistance exercises performed by an upper limb influence the contralateral lower limb muscles contraction (continue movement)\(^9,10\), and the systemic balance reaction was occurred to the contralateral lower limb. The effect of the “continue movement” was emphasized in the isometric resistance exercise performed by an upper limb at the final position. In this upper limb position, the extension force of the contralateral lower limb was increased significantly, more so in the PNF movement than in the shoulder movement.

Previous studies of PNF reported neurophysiological considerations. When an upper limb was held in the PNF pattern, reaction times were shortened\(^11\), acceleration of upper or lower limb movements were improved, brain waves changed\(^12,13\) and the H wave of the soleus muscle was amplified\(^14–16\). These studies attempted to delineate the effects of PNF pattern of an upper limb on the other parts of a person. It has also been suggested that PNF movement increases the wakefulness level of the upper motor center and the excitability of the spinal cord motor neuron\(^17\).

In this study, isometric resistance exercises performed by an upper limb became holding of PNF pattern. Isometric resistance exercises performed by an upper limb initiated the “continue movement” in trunk extensor muscles and the contralateral lower limb, because PNF patterns are diagonal and spiral movements. The “continue movement” from an upper limb to the contralateral lower limb was particularly clear in the isometric resistance exercise by the upper limb at the final position of PNF movement. The increase of muscle activities of the lower limbs occurred because the trunk and lower limbs became fixed to guarantee the upper limb movement.

The mean of %MVIC of the extension forces of the lower limbs when isometric resistance exercise was performed by an upper limb at the final position of PNF movement was shown 54.3 ± 22.4%MVIC. This value is required for muscle strengthening and maintenance exercises by the isometric contraction\(^18–20\). Therefore, we demonstrated the effect of indirect treatment.

In conclusion, we showed that indirect treatment is effective. These results may lead to the development of treatments for patients who have in voluntarily moving their lower limbs difficulty.

**REFERENCES**

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