The Effect of PNF Position of the Upper Extremity on Rapid Knee Extension

MASAAKI FUJITA and RYUICHI NAKAMURA

Institute of Rehabilitation Medicine, Tohoku University
School of Medicine, Narugo, Miyagi 989-68


Premotor time (PMT) and maximum tension \( F_{\text{max}} \) produced by isometric contraction of the left and the right quadriceps femoris for rapid knee extension were examined in 10 normal male subjects at two positions of the left upper extremity, neutral and facilitating position for the triceps brachii. Compared to the neutral position, PMT of the both sides decreased and \( F_{\text{max}} \) increased at the facilitating position, while the contraction time did not change. It is assumed that the facilitating position brings about generalized activation of the central nervous system resulting in behavioral alertness.

It is empirically known that facilitating positions utilized in proprioceptive neuromuscular facilitation (PNF) technique make it easy for a subject to start and carry out patterned movements. Recent studies indicated that facilitating positions induced behavioral alertness, since premotor time (PMT) of the triceps brachii muscle, a latency from a response signal to the onset of EMG activities of the muscle, was short at the facilitating position compared to neutral or kinesiological reference position (Nakamura and Viel 1974; Taniguchi et al. 1980), and also indicated that vocal reaction time was faster at facilitating position of the upper or the lower extremity than at the neutral position (Nakamura 1983). Although facilitating positions generally decrease PMT, their effect on force output in a reaction time study has not been examined. In this study, we analyzed force output of rapid knee extension at two positions of the upper extremity, neutral and facilitating position for the triceps brachii (Nakamura and Viel 1974), and attempted to examine whether shortening of PMT was coupled with any change of force output.

METHODS

Ten healthy male subjects aged from 27 to 50 years participated in the study. The experimental apparatus has been reported in detail (Nagasaki and Nakamura 1985). The subject sat on a chair with the trunk upright, and the hip and the knee flexed at 90 degrees. A strap with two ropes was attached to distal end of the leg. The one rope was connected...
with the weight of 2 kg via a pulley, pulling the leg forward. The other one was connected with a tension meter (T.K.K. Dynamometer, Takei-Kiki, Tokyo), pulling the leg backward (Fig. 1).

The subject was asked to extend the knee as rapidly and forcefully as possible, responding to a sound stimulus (1 kHz, 50 msec duration) presented 2 sec after a warning signal. The trials were performed at the two positions of the left upper extremity; neutral

---

Fig. 1. Setup for measurement of PMT and force output on rapid knee extension. W, weight-loaded; EMG, surface EMG of the rectus femoris muscle; and TM, tension meter.

---

Fig. 2. Schematic presentation of EMG and tension curve. PMT: latency from the sound stimulus to the onset of EMG activities. TLT, latency from the onset of EMG activities to T1 which is the timing of the rise of tension; FT\text{max}, latency from T1 to the maximum contraction; F\text{max}, maximum tension.
Effect of PNF Position on Force Output 33

position, the forearm supported by a horizontal forearm rest making the elbow at 90 degrees flexion and the shoulder at kinesiological reference position; and facilitating position, the elbow and the forearm passively supported by an examiner making the shoulder at 135 degrees abduction, 45 degrees horizontal adduction and 30 degrees internal rotation, and the elbow at 90 degrees flexion (Nakamura and Viel 1974), while the right upper extremity was kept at the neutral position by the horizontal forearm rest. Each subject submitted to a training session to be familiar with the procedure and after that the experimental session was carried out. Ten trials were performed at each position with the inter-trial intervals more than 10 sec. The two positions were alternately changed every five trials in a fixed order of neutral-facilitating-neutral-facilitating. The response of the left side was firstly examined, followed by the right on a different day.

EMG activities taken from the rectus femoris muscle with surface electrodes were amplified and displayed on a memoscope (ATAC-350, Nihon-Koden, Tokyo), which was triggered by an electric pulse synchronized with the sound stimulus. The latency from the sound stimulus to the onset of EMG activities, referred to as PMT, was measured on the memoscope with a msec scale.

Output of the tension meter was fed to a microcomputer (PC-9801F, NEC, Tokyo) via an A/D converter with a sampling frequency of 1 kHz. Fig. 2 shows three variables measured in the experiment: tension lag time (TLT), the latency from the onset of EMG activities to the rise of tension; contraction time (FT\textsubscript{max}); and maximum tension (F\textsubscript{max}). To test the statistical significance of difference in the mean values of PMT, TLT, FT\textsubscript{max} and F\textsubscript{max} between the neutral and the facilitating position, Student’s paired t-test and unpaired t-test were used. For all statistical analyses, \( p < 0.05 \) was accepted as significant.

| Table 1. Values of premotor time (PMT), tension lag time (TLT), contraction time (FT\textsubscript{max}) and maximum tension (F\textsubscript{max}) |
|---|---|---|---|---|
| **Left lower extremity** | | | | |
| Position | PMT (msec) | TLT (msec) | FT\textsubscript{max} (msec) | F\textsubscript{max} (kg \cdot m) |
| N | 126.9 (14.2) | 32.5 (5.7) | 112.2 (9.8) | 5.81 (1.59) |
| F | 120.6 (16.2) | 31.6 (6.7) | 112.4 (10.2) | 6.78 (2.17) |
| D (N − F) | 6.3* (6.6) | 0.9 (3.4) | −0.2 (2.4) | −0.97* (0.89) |
| **Right lower extremity** | | | | |
| Position | PMT (msec) | TLT (msec) | FT\textsubscript{max} (msec) | F\textsubscript{max} (kg \cdot m) |
| N | 123.6 (14.8) | 30.5 (4.1) | 109.1 (11.3) | 6.45 (1.34) |
| F | 119.4 (17.9) | 31.6 (4.8) | 111.4 (9.6) | 7.27 (1.57) |
| D (N − F) | 4.2* (5.2) | −1.1 (1.9) | −2.3 (4.4) | −0.82** (0.49) |

N, neutral; F, facilitating; D, difference between the N and the F position. Values are given in terms of means and s.d. in parentheses.

*\( p < 0.05 \); **\( p < 0.01 \).
RESULTS

Table 1 presents overall means and SDs of PMT, TLT, FT_{max} and F_{max} for each position. There was a significant difference of PMT between the neutral and the facilitating position both on the left and the right side ($p < 0.05$, respectively). PMTs of the left and the right rectus femoris were faster at the facilitating position than at the neutral. The differences of TLT and FT_{max} between the neutral and the facilitating position were not significant both on the left and the right side. Concerning the variables representing the temporal event of rapid force generation, that is, PMT, TLT and FT_{max}, only PMT was influenced by the position of the upper extremity.

The difference of F_{max} between the neutral and the facilitating position was significant both on the left ($p < 0.05$) and the right side ($p < 0.01$). Thus, the facilitating position increased the force output for rapid knee extension without shifting its time course.

The mean differences in PMT (d-PMT) and F_{max} (d-F_{max}) between the neutral and the facilitating position, subtracting PMT and F_{max} of the facilitating position from those of the neutral position, were calculated for all subjects. No significant differences in d-PMT and d-F_{max} were found between the left and the right side.

DISCUSSION

The present results indicated that the facilitating position for the left triceps brachii decreased PMT of the rectus femoris for knee extension and increased its force output on the both sides without shifting the time course of rapid force generation. The lack of differences in d-PMT and d-F_{max} between the both sides points out that the effect of facilitating position of one upper extremity is the same on both the ipsilateral and the contralateral lower extremity.

There are two possible mechanisms concerning the increased force output at the facilitating position; first, influence of propriospinal reflex and secondly, generalized activation of the central nervous system.

Delwaide et al. (1977) reported that the quadriceps tendon reflex was facilitated by passive flexion of the ipsilateral shoulder and was inhibited by passive flexion of the contralateral shoulder, and suggested that the effect of postural changes on the tendon reflex was mediated by long propriospinal neurons. Assuming that the effect of facilitating positions of the upper extremity on force output of the quadriceps femoris is mediated by the same spinal mechanism, the force output of the one side should increase and that of the other should decrease in a reciprocal fashion. The present results, however, did not support this assumption, implying that the effect of propriospinal reflex is not acting on motoneurons of the quadriceps femoris at the initiation of knee extension.

Facilitating positions bring about EEG arousal reflecting cortical activation;
For instance, the mean frequency and the mean power of alpha band of EEG are higher at facilitating positions of the upper or the lower extremity than at neutral position (Chida and Nakamura 1983; Hosokawa et al. 1985). Both EEG and reaction time studies suggest that facilitating positions induce generalized activation of the central nervous system. Also it is well known that the elevation of arousal by subject's own outcry or by a loud noise increase the muscle strength (cf. Ikai and Steinhaus 1961). Considering these reports, generalized activation of the central nervous system would be a primary cause of the increased force output at facilitating positions. According to Kahneman (1973), the completion of a mental activity requires two types of input to the corresponding structure: an information input specific to that structure and a nonspecific input referred to as capacity, and the arousal is closely related to the capacity. Since the information input about the motor task was not manipulated in the present study and the shifting of arousal level was definitely produced by the postural change, the increase of capacity took place and resulted in the decreased PMT and the increased force output.

References