Influence of electrical stimulation on hip joint adductor muscle activity during maximum effort

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Abstract. [Purpose] This study investigated whether hip adductor activity was influenced by electrical stimulation of the tensor fascia lata muscle. [Subjects and Methods] The subjects were 16 nondisabled males. Each subject was asked to adduct the hip joint with maximum effort. The electromyogram of the adductor longus was recorded under two experimental conditions, with and without electrical stimulation of the tensor fascia lata. [Results] In the presence of electrical stimulation, muscle activity decreased to 72.9% (57.8–89.3%) of that without stimulation. [Conclusion] These results suggested that inactivation of the adductor group was promoted by electrical stimulation of the tensor fascia lata.

Key words: Electrical stimulation, Adductor longus, Muscle activity

INTRODUCTION

It is difficult for bedbound elderly people who are receiving long-term care to use the toilet1). Therefore, they often have to wear diapers, which are changed by caregivers. Bedbound elderly people often have a limited range of movement because of articular or muscular contractures2). This can make changing diapers more difficult if passive abduction is affected because the hip joint is fixed in adduction. Therefore, it is necessary to prevent contractures in order to secure sufficient passive hip abduction. Leaving the hip in the adducted position causes the onset and progression of contractures3), and physical therapy with passive motion can prevent this. However, our experience as physical therapists has suggested that passive motion exercises are embarrassing for patients and resistance occurs due to excessive contraction of the antagonist muscles; the best solution in such cases is still unclear. Recently, we demonstrated that hip adduction power was decreased in healthy adults by electrical stimulation of the tensor fascia lata muscle4), suggesting that voluntary maximum contraction of the hip adductor muscles was suppressed by stimulating the tensor fascia lata. This effect is considered to be due to reciprocal inhibition at the spinal cord level, which is caused by stimulation of group Ia fibers5). However, we could not determine whether suppression of hip adductor activity occurred in our previous study4), i.e., whether there was reciprocal inhibition, when electrical stimulation of the tensor fascia lata was performed.

Evoked or surface electromyography (EMG) is used to explore the occurrence of reciprocal inhibition. The evoked EMG can measure the latency, threshold, and anteroposterior excitability at the onset of voluntary exercise, which allows investigation of the type of inhibitory mechanism6). However, although induction of the H-reflex of the soleus and flexor carpi radialis muscles is commonly performed, this method has not been applied to the adductors of the hip joint6–7). In contrast, the surface EMG measures inhibition of the α motor neuron pool during muscle contraction8). Therefore, this study employed surface EMG to detect the occurrence of reciprocal inhibition of adductor activity by electrical stimulation of the tensor fascia lata.
SUBJECTS AND METHODS

The subjects were 16 nondisabled males who agreed to participate. Their mean age, height, and weight were 23.1 years, 169.9 cm, and 63.4 kg, respectively (Table 1). Before the initiation of exercise, the hip joint on the side of measurement was set in 60° of flexion and 10° of adduction with the subject in the supine position9). Each subject was asked to voluntarily adduct the hip joint with maximum effort. A pad was fixed on the medial epicondyle of the femur to ensure isometric contraction during adduction. The experiment was performed under the following two conditions. (1) The subject performed hip joint adduction without electrical stimulation (off-ES). (2) After 1 h of rest, the subject performed the same exercise with electrical stimulation (on-ES). Before each exercise session, we verbally confirmed that the subjects had not experienced myalgia. An EMG (Master km-818; Mediarea Support Business Union, Okayama, Japan) was used to measure muscular activity. The EMG of the adductor longus muscle was recorded using bipolar disposable surface electrodes (Ag-AgCl Blusensor, Mets Inc., Tokyo, Japan) with a 20-mm interelectrode distance and a sampling frequency of 1 kHz. Under each experimental condition, the subject performed maximum isometric contraction for 5 s, and data were compared from 2 s to 4 s after the initiation of contraction. Measurement was carried out three times at 5-min intervals for the purpose of avoiding muscle fatigue, and the mean measured value was adopted as the representative result for each condition. Electrical stimulation was applied to the tensor fascia lata muscle using PROTECHNO PNF PRIME (2.7 kHz; pulse, 156 μs, Alpha Trinity Inc., Osaka, Japan) with a 100-mm interelectrode distance. In this experiment, the current was selected with respect to the occurrence of muscle contraction and severe pain. The current ranged from 35 to 50 mA, with an average of 40 ± 3 mA. During electrical stimulation, muscular contraction was confirmed by using a PEK-1 muscle hardness meter (Imoto Machinery Co., Ltd., Kyoto, Japan). It was verified that joint motion did not occur on contraction of the muscle during the 5-min rest period. In the on-ES condition, the subject was asked to begin maximum isometric contraction after electrical stimulation was initiated. However, measurement of muscle activity was difficult because the stimulating electrical current was also recorded by EMG. Therefore, in the on-ES condition, electrical stimulation was interrupted at 2 s after initiation of a contraction. After full-wave rectification was performed, the mean EMG amplitude was calculated. Muscle activity during the on-ES condition was determined relative to activity during the off-ES condition, which was set as 100%8). All data were analyzed using standard statistical software (IBM SPSS Statistics ver. 19.0, IBM Japan, Ltd., Tokyo, Japan). The Wilcoxon signed rank test was performed to compare muscle activity under the two experimental conditions, and p<0.01 was considered significant. This study was conducted in accordance with the ethical principles of the Declaration of Helsinki and was approved by the Ethics Committee of the Kyushu University of Nursing and Social Welfare.

RESULTS

Table 2 shows a comparison of muscle activity between the two conditions. It was found that muscle activity was significantly lower in the on-ES condition than in the off-ES condition. When muscle activity in the off-ES condition was set as 100%, the level of activity in the on-ES condition was 72.9% (57.8–89.3%). Figure 1 shows a representative example of muscle activity recording.

DISCUSSION

In this study, we found that electrical stimulation of the tensor fascia lata during maximum hip joint adduction reduced the contraction of the adductor longus muscle. Previous studies have suggested that spasticity can be improved by electrical stimulation of antagonist muscles9). With regard to the mechanism involved, it has been suggested that when the antagonist of the spastic muscle receives electrical stimulation, Ia reciprocal inhibition of the spastic muscle occurs11). In healthy people, electrical stimulation of the tibialis anterior muscle has been demonstrated to increase Ia reciprocal inhibition in the soleus muscle12). In the present experiment, it is likely that the nerve fibers received electrical stimulation exceeding the threshold because tetanic contraction of the tensor fascia lata was produced by stimulation. Moreover, muscle activity decreased after 2 s when electrical stimulation was discontinued (*2 in Fig. 1). These findings suggested that the decrease in muscle activity of the adductors was caused by the increase of reciprocal inhibition to the adductors by electrical stimulation to the tensor fascia lata muscle, and the sustained effect after cessation of electrical stimulation13).

As a limitation of this study, muscle activity was difficult to record during electrical stimulation. However, a decrease of maximum adduction force was observed in our previous study when electrical stimulation was applied14). In addition, inhibition has been reported to commence from several to tens of milliseconds after initiation of electrical stimulation15). Therefore, electrical stimulation was conducted 1–2 s before voluntary contraction in this study, and the results suggested that inhibition was increased during electrical stimulation. Because the threshold of electrical stimulation was not lower than the M-wave threshold, we were unable to exclude the possibility that there was an influence on other pathways in addition to disynaptic Ia reciprocal inhibition. Despite these limitations, our findings suggested that inactivation of the adductor muscle group was promoted by electrical stimulation of the tensor fascia lata. Further, we suggest that reciprocal inhibition was one of the factors involved in inactivation of the adductors. Further studies will be necessary to identify the details of the inhibitory pathway.
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