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Effect of Insertion Phases of Unilateral Shoulder Flexion and Extension on Walk-Like Lower Limb Exercise with The Crossed Innervation Acted

Hiroshi TOYAMA[1] and Katsuo FUJIWARA[1]

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1. Introduction

According to the progress of motor learning, the motor control of voluntary movement is automatized in company with shift of the neural centers of motor control to the lower neural centers[4,6]. Toyama and Fujiwara[8,9,11] obtained the phenomena that the automatized level of motor control could be evaluated by the interference degree between the upper limb exercise and lower limb exercise. By analyzing of the interference degree of the upper limbs exercise to the walking exercise, we obtained the result that the motor control of the lower limbs during the walking exercise of adult subjects was highly automatized[10].

An automatization of motor control implies a change of the regulation which shift toward reflexibility. The simultaneous control of the upper limb and lower limb is based on the neural linkage between those limbs[1,2]. Therefore, the functional state of the interlimb reflex in the voluntary control may be reflected on the aspect of the interference.

From this view point, we investigated the effect of insertion phases of unilateral shoulder flexion and extension on the walk-like lower limb exercise with the crossed innervation acted.

2. Methods

The subjects were 9 males, aged from 18 to 37 years old (table 1). The subjects performed the stepping with holding their upper limbs in lateral side of the body, in the frequency of 120 times/min. They performed a slight flexion or

Table 1 Age, Hight and Weight of the subjects

	Age (years)	Hight (cm)	Weight (kg)
n	9	9	9
mean	22.4	168.3	61.7
S. D.	6.24	3.68	9.33

1) Department of Health and Physical Education, College of Liberal Arts, Kanazawa University, 1-1 Marunouchi, Kanazawa, 920 Japan.

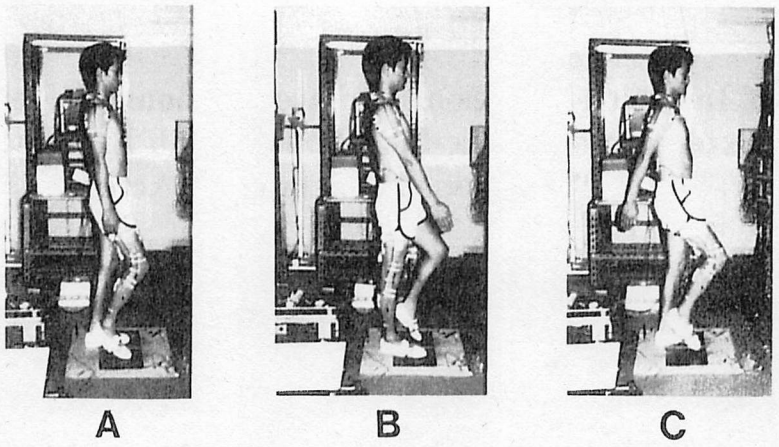

Fig. 1 Measurment of the interference of the unilateral shoulder movement to the walk-like lower limbs exercise (A : stepping without shoulder motion. B : insertion of shoulder flexion. C : insertion of shoulder extension).

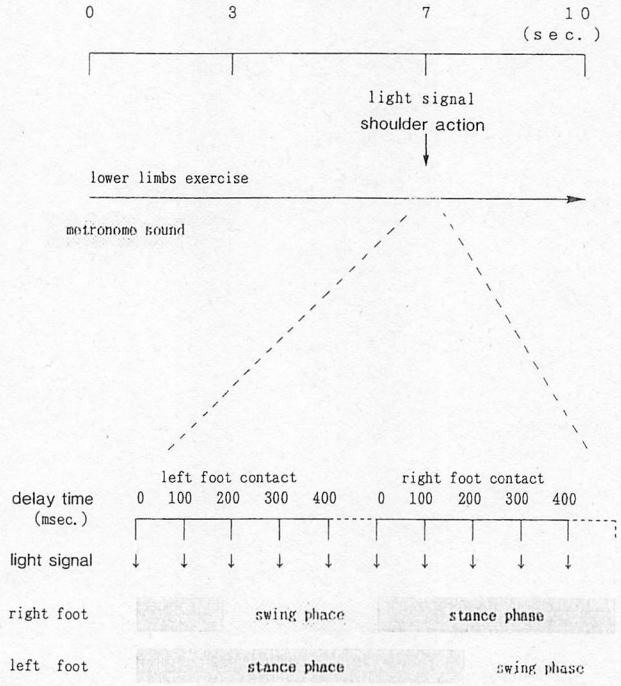

Fig. 2 Experimental schedule.

extension (about 20 degrees) of right shoulder in response to a light signal while stepping (figure 1). A light signal were presented at 0, 100, 200, 300 and 400 msec after the contact of right or left foot, using a delayed signal generator (HIRUTA M. E., model HFT-907). Figure 2 shows the experimental schedule. In these signal conditions, 6 trials were carried out respectively. The subjects were given the instruction to maintain the step cycle and

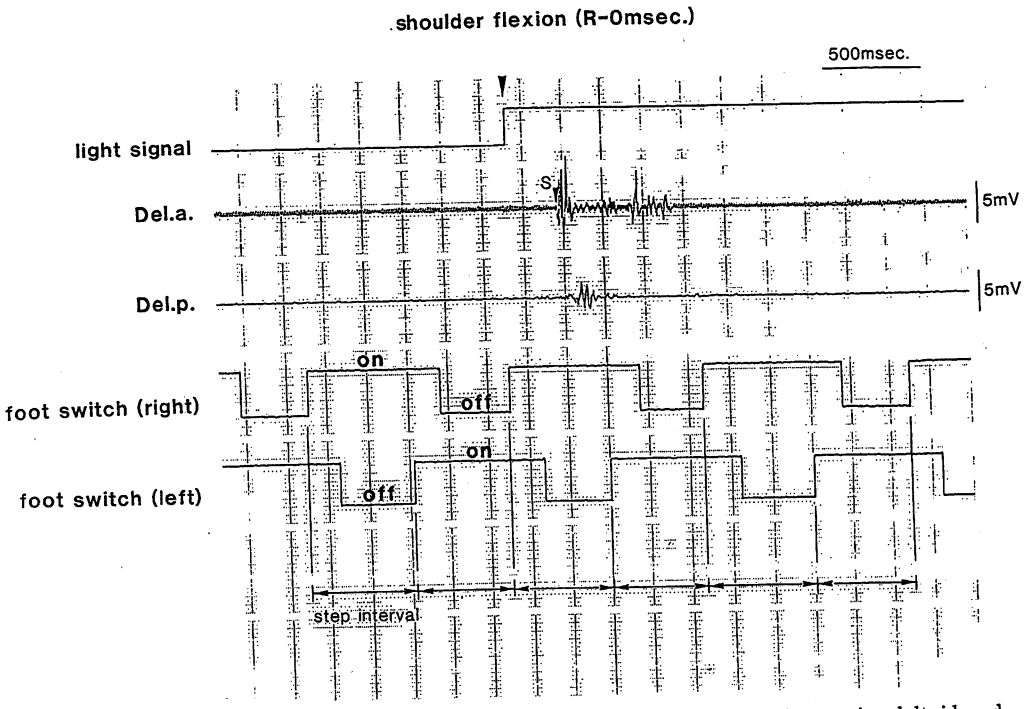

Fig. 3 Typical recording of a light signal, EMGs of anterior deltoid and posterior deltoid and footswitch signals.

performe the shouler movement in response to a light signal as soon as possible. The footswitch signals of both feet, electromyographies (EMGs) of anterior deltoid muscle (DA) and posterior deltoid muscle (DP) of right side were picked up. The time interval of the alternate foot contacts (step interval) and the muscle onsets of DA and DP were analyzed using a micro computer (EPSON, PC-286LS). In the A/D conversion, a resolution was 12 bitt and a sampling interval was 2 msec. The interference degree of the insertion of shoulder movement to the walk-like lower limbs exercise was evaluated by the change of step interval.

In addition, the relation between the motion of right shoulder joint and the EMG activities was investigated while stepping with the movement of both sides of shoulder (the natural stepping).

The significant level of t-test used in this study was 5%.

3. Results

Figure 3 shows the typical recording of a light signal, EMGs of DA and DP and footswitch signals in the condition of shoulder flexion.

In the condition of shoulder flexion, one step interval in which the onset of DA activity

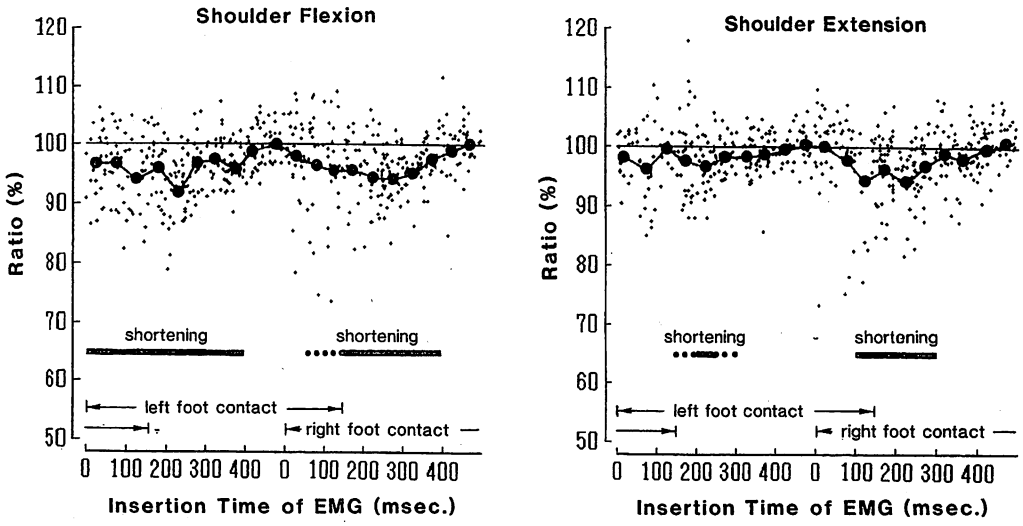

Fig. 4 Ratio of one step cycle (the summation of one step interval in which the muscle onset of deltoid was contained and one step interval following by it) to that just prior to it.

was contained or one step interval following by it, or both were shortened in a specific phase of stepping. Figure 4 shows the ratio of one step cycle (the summation of these two step intervals) to that just prior to it (SC-ratio). When the muscle onset of DA existed between 0 msec and 398 msec after left foot contact and between 150 msec and 398 msec after right foot contact, the SC-ratio was significantly decreased.

The similar phenomena were obtained in the condition of shoulder extension. When the muscle onset of DP existed between 100 msec and 298 msec after right foot contact and between 200 msec and 248 msec after left foot contact, the decrease of SC-ratio was significant.

In the natural stepping, the timing that right shoulder changed the movement direction in back was 357±27.3 msec after the left foot contact. The timings of onset, peak and end in the EMG of DA were 290±44.9 msec after the left foot contact, 428±40.9 msec after that and 16±45.1 msec after the right foot contact, respectively. The timing that right shoulder changed the movement direction in front was 348±25.9 msec after the right foot contact. The timings of onset, peak and end in the EMG of DP were 88±78.9 msec after the right foot contact, 418±88.4 msec after that and 93±67.0 msec after the left foot contact, respectively.

Figure 5 shows the muscle activities in the natural stepping and the time range of muscle onsets of DA and DP in which the SC-ratio significantly decreased in two conditions of the shoulder movement.

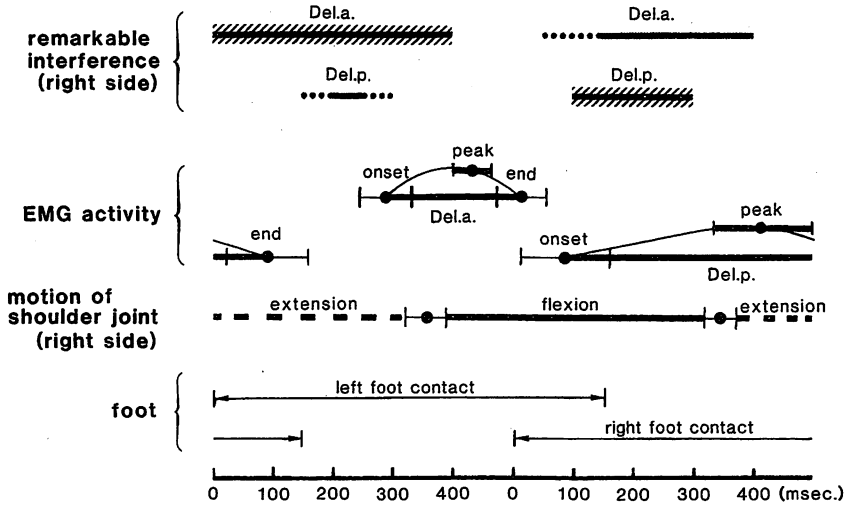

Fig. 5 Muscle activities in the natural stepping and the time range of muscle onsets of anterior and posterior deltoid in which the step cycle ratio significantly decreased.

4. Discussion

Patla[7] reported that the right shoulder flexion shortened the durations of the stance and swing phases relate to the walking cycle. However, the shoulder flexion was so forceful and large that these changes may be due to not only the neural connection between the upper limb and lower limb but also the physical factor. In this study, we utilized a slight movement of shoulder in order to prevent the physical change. Nevertheless, the remarkable decrease of SC-ratio appeared. This interference may be produced under the neural connection between the upper and lower limb.

The remarkable interference of the shoulder movement was appeard on two phases in the step cycle. One of them was when the activities of DA and DP started before the peak of their muscle activities in the natural stepping. Another phase corresponded to the time that these muscles were not activated in the natural stepping. It seems that the former phenomenon is the contralateral facilitation and the latter phenomenon is the ipsilateral facilitation for the lower limb which are caused by an insertion of shoulder movement. However, the time range that the contralateral facilitation existed was wider than that of the ipsilateral facilitation. Lloyd[5], Gernandt and Shimamura[3] reported that the crossed and uncrossed neural pathways existed between the forelimbs and hindlimbs in cat. In addition, they showed that the crossed neural linkage was more strong than the uncrossed one. As well as animal, the strong crossed neural linkage between the upper and lower limbs has been shown in man[1].

It is conceivable that the results in this study suggest an aspect of integration of the interlimb reflex in the voluntary control of upper limb exercise during the walk-like lower limb exercise.

5. Summary

From the point of view that how the interlimb reflex function in the voluntary control of upper limb exercise during the walk-like lower limb exercise, we examined the effect of insertion phases of unilateral shoulder flexion and extension on the walk-like lower limb exercise. Nine male subjects performed stepping with holding their upper limbs in lateral side of the body, in the frequency of 120 times/min. They performed a slight flexion or extension of right shoulder in response to a light signal while stepping. A light signal were presented at 0, 100, 200, 300 and 400 msec after contact of right or left foot. The summary of the results was shown below.

1) In the condition of shoulder flexion, when the muscle onset of anterior deltoid existed between 0 msec and 398 msec after left foot contact and between 150 msec and 398 msec after right foot contact, one step interval in which the onset of anterior deltoid activity was contained or one step interval following by it, or both were significantly shortened.

2) In the condition of shoulder extension, when the muscle onset of posterior deltoid existed between 100 msec and 298 msec after right foot contact and between 200 msec and 248 msec after left foot contact, one step interval in which the onset of anterior deltoid activity was contained or one step interval following by it, or both were significantly shortened.

3) In both conditions of the shoulder movement, the remarkable shortening of step cycle was appeard on two phases in the step sycle. One of them was when the activities of anterior and posterior deltoid started before the peak of their muscle activities in the natural stepping. Another phase was corresponded to the time that these muscles were not activated in the natural stepping.

It is conceivable that these results suggest an aspect of integration of the interlimb reflex in the voluntary control of upper limb exercise during the walk-like lower limb exercise.

References

1) Delwaide, P. J., Figiel, C. and Richelle, C. (1977) Effects of postural changes of the upper limb on reflex transmission in the lower limb. J. Neurosurg. Psychiat., 40, 616-621.

2) Gernandt, B. E. and Megirian, D. (1961) Ascending propriospinal mechanisms. J. Neurophysiol., 24, 364-376.
3) Gernandt, B. E. and Shimamura, M. (1961) Mechanisums of interlimb reflexes in cat. J. Neurophysiol., 24, 665-676.
4) Jackson, J. H. (1898) Relations of different divisions of the central nervous system to one another and to parts of the body. Lancet, In : Selected writings of John Hughlings Jackson, vol. II, Tailor, J. (Ed.), (1932), Hodder and Stoughton, London, 422-443.
5) Lloyd, D. P. C. (1942) Mediation of descending long spinal reflex activity. J. Neurophysiol., 6, 435-458.
6) Paillard, J. (1960) : The patterning of skilled movement. In : Handbook of physiology, section 1 : Neurophysiology, vol. III, Field, J. (Ed.), American Physiological Society, Washngton, 1679-1708.
7) Patla, A. E. (1986) Adaptation of postural response to voluntary arm raises during locomotion in humans. Neurosci. Letters, 68, 334-338.
8) Toyama, H. and Fujiwara, K. (1990) Interference of upper limbs exercise to the perodic lower limbs exercise with different automatized levels. Jpn. J. Phys. Fitness Sports Med., 39, 44-52.
9) Toyama, H. and Fujiwara, K. (1990) Interference between upper limbs exercise and the lower limbs exercise in rhythmical skill trainees of upper limb. Biomechanics 1990, Japanese Society of Biomechanics (Eds.), Medical Press, Tokyo, pp. 103-107.
10) Toyama, H., Fujiwara, K., Asai, H. and Yamashina, T. (1990) Interference of a single upper limbs exercise on the walking cycle. Jpn. J. Hum. Posture, 10, 143-148.
11) Toyama, H. and Fujiwara, K. (1991) Interference between upper limbs exercise and lower limbs exercise. Ann. Sci. Kanazawa Univ., 28, 39-47.