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ORIGINAL ARTICLE

THE RELATIONSHIP BETWEEN ARM SWING AND WALKING ABILITIES IN HEMIPLEGIA PATIENTS

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Abstract **Background:** In hemiplegia cases having upper and lower extremity disorders, arm swing is seldom the priority of consideration. One of the reasons is that the purpose of arm swinging has not yet been clarified.
Objective: To investigate the effect of arm swing on walking abilities of hemiplegia case.
Method: 17 hemiplegia stroke patients participated in this study. The subjects performed a 10m walking test randomly with 4 different conditions of arm swing while the time, steps taken and pelvic fluctuation were measured. The 4 conditions were: 1) normal gait, 2) single arm restricted gait, 3) both arm restricted gait, and 4) maximum arm swing gait. The outcomes were analyzed by multiple comparison with a significance level of less than 5%.
Results: There were no significant differences in gait parameters between the conditions of arm swing. Thus, the subjects were sorted based on their severity of hemiplegia (Brunnstrom recovery stage). In medium severity of hemiplegia cases (Brunnstrom stageⅢ-Ⅳ), the patients tended to, when swinging only the non-paralyzed arm have a greater velocity and step length. On the other hand, in low severity of hemiplegia cases (Brunnstrom stageⅤ), the patients showed the same tendencies as the healthy adults showed in a previous study.
Conclusions: It may have an impact on walking abilities if stroke patients swing their non-hemiplegia side arm while wearing an arm sling but this needs further investigation.

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Key words: arm swing; walking abilities; hemiplegia cases.

Introduction

The upper limb is swung by reversing the phase with the lower limbs during walking. It is assumed that this works to counteract the longitudinal rotation of the trunk in order to smoothen the walking motion[1)]. In natural walking, the upper limb is swung forward by 20° and backward by 9°[2)]. Aratani reported that by limiting upper limb swing in healthy subjects, walking velocity and stride length were reduced[3)]. The function of the upper limb in walking supplements the insufficient balance function at the beginning of walking, the fluctuation of the center of gravity gradually reduces and thus walking efficiency increases. According to Ferris et al, patients with severe paralysis report that upper limbs are fixed and alternating gait becomes difficult to compensate for balance function[4)]. Stephenson et al reported increase in stride length during walking with swinging upper limbs in stroke patients[5, 6)]. On the other hand, Pijnappels and Bruijn have reported that the swing of the upper limb does not improve walking stability[7, 8)]. As described above, there are studies describing both the merits and demerits of the swinging upper limbs in a patient with stroke hemiplegia. However, the upper limb swing function during walking is still unknown[9)]. Therefore, the purpose of this study was to investigate the relationship between the swing of the upper limb in patients with stroke hemiplegia and the walking abilities.

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Method

17 patients of stroke (13 males, 4 females, 66.8 ± 9.7 years of age) participated in this study. The diagnosis was cerebral infarction in 13 cases and cerebral hemorrhage in 4 cases. The time from the onset was 101.3±36 days. Brunnstrom stage of the upper extremities was III in 4 cases, IV in 10 cases and V in 3 cases. That of the lower extremities was III in 1 case, IV in 6 cases and Vin 10 cases. Berg Balance Scale score was 49.6±4.2. Mini Mental State Examination score was 26.5±2.9. All patients were hospitalized in the Hirosaki Stroke Rehabilitation Center. The inclusion criteria were that the subjects were required to be able to perform a 10m walk test with no walking aid. Patients with problems in understanding such as cognitive impairment and aphasia, having psychological problems due to psychiatric disorders and depressive conditions, having upper and lower limb orthopedic diseases with pain, or having high risk due to cardiorespiratory disorder or autonomic nervous symptoms were excluded from the study. This study was carried out under the permission of the Hirosaki Stroke Rehabilitation Center Ethics Committee (approval number: 15B007).

Subjects were asked to perform a 10m walk test once under each of the following four conditions. a) free gait, b) single arm restricted gait in which the paralyzed hand was restricted with an arm sling, c) both arms restricted gait in which the paralyzed hand was restricted with an arm sling and non-paralyzed arm was restricted with a strap, and d) maximum arm swing gait in which subjects were instructed to swing both arms as much as they could. Lower limb orthosis could be worn by those who daily use it. The data of time and number of steps for the 10m walking test were taken. During the test, a multi-measurement device, Corpus, was attached between the upper and back iliac spines of subjects to analyze pelvic fluctuation with the standard deviation of acceleration in 3 axes of the pelvis. After completing the test, the subjects were asked to answer a questionnaire on how they felt about the conditions.

With respect to each condition, multiple comparison test was performed on velocity, stride, cadence, and pelvic fluctuation. The questionnaire was calculated with simple tabulation. SPSS for Windows Ver 16.0 J was used for statistical analysis, with significance level less than 5%.

Result

No significant difference in velocity, stride length, cadence or fluctuation of pelvis between the gait conditions was observed (Fig. 1). However, when we sorted the subjects into groups by the severity of paralysis, 7 patients with severe paralysis (Brunnstrom stage III-IV) tended to decrease in walking ability in the order of single arm restricted, maximum arm swing, free gait, both arms restricted (Fig. 2). Meanwhile, 10 patients with mild severity of paralysis (Brunnstrom stage V) tended to decrease in walking ability in the order of free gait, maximum arm swing, single arm restricted, both arms restricted (Fig. 3). As for the questionnaire, 59% of patients answered that both arms restricted gait was the most difficult condition, while 47% answered that single arm restricted gait was the easiest condition.

Discussion

In this study, we examined the influence of arm swing on walking ability of stroke patients. However, no statistically significant difference was found between the conditions in all the parameters. Hashidate et al reported about the difference between maximum and comfortable walking time of the 10m walking test and Time Up and Go Test as the preliminary walking ability[10]. Elderly people and stroke patients were

Figure 1 Average value of walking parameters under 4 conditions (n=17)

	Velocity (m/min)	Stride length (m)	Cadence (steps/min)
Free gait	53.03 ± 18.07	0.45 ± 0.10	114.83 ± 17.89
Single arm restricted gait	51.53 ± 14.36	0.45 ± 0.09	113.15 ± 16.31
Both arms restricted gait	50.31 ± 15.73	0.44 ± 0.09	112.81 ± 18.39
Maximum arm swing gait	53.00 ± 16.14	0.45 ± 0.09	115.52 ± 18.59

Average ± standard deviation

	Acceleration of pelvis (m/s^2)		
	X-axis	Y-axis	Z-axis
Free gait	± 0.16	± 0.21	± 0.18
Single arm restricted gait	± 0.16	± 0.21	± 0.17
Both arms restricted gait	± 0.14	± 0.21	± 0.16
Maximum arm swing gait	± 0.17	± 0.22	± 0.18

± standard deviation

Figure 2 Average value of walking parameters of severe paralysis patients under 4 conditions (n=7)

	Velocity (m/min)	Stride length (m)	Cadence (steps/min)
Free gait	38.08 ± 10.83	0.375 ± 0.07	100.12 ± 11.33
Single arm restricted gait	40.23 ± 12.43	0.392 ± 0.08	101.04 ± 13.85
Both arms restricted gait	37.54 ± 10.74	0.375 ± 0.08	98.90 ± 9.98
Maximum arm swing gait	39.67 ± 11.92	0.386 ± 0.08	101.23 ± 12.66

Average ± standard deviation

	Acceleration of pelvis (m/s^2)		
	X-axis	Y-axis	Z-axis
Free gait	± 0.178	± 0.166	± 0.214
Single arm restricted gait	± 0.157	± 0.188	± 0.193
Both arms restricted gait	± 0.147	± 0.160	± 0.191
Maximum arm swing gait	± 0.169	± 0.190	± 0.208

± standard deviation

reported to be low in this ability[11]. Therefore, when swinging arms during walking, stroke patients might be slowing down the walking speed to maintain balance. As a result, it seems that there was no difference by arm swinging but, observing the results of both arms restricted gait, walking velocity, stride length and cadence were lowest. According to Ferris et al, patients with severe paralysis report when upper limbs are fixed it becomes difficult to compensate for balance function[4].

Although there was no significant difference overall, when looking at measured values, the cases with severe lower limb paralysis were better in the order of both arms restricted, free gait, maximum arm swing, single arm restricted.

Figure 3 Average value of walking parameters of mild paralysis patients under 4 conditions (n=10)

	Velocity (m/min)	Stride length (m)	Cadence (steps/min)
Free gait	63.49 ± 14.37	0.504 ± 0.08	125.13 ± 14.03
Single arm restricted gait	59.43 ± 9.75	0.489 ± 0.07	121.63 ± 12.28
Both arms restricted gait	59.24 ± 12.14	0.484 ± 0.07	122.54 ± 16.70
Maximum arm swing gait	62.33 ± 11.54	0.497 ± 0.07	125.53 ± 15.41

Average ± standard deviation

	Acceleration of pelvis (m/s^2)		
	X-axis	Y-axis	Z-axis
Free gait	±0.145	±0.248	±0.125
Single arm restricted gait	±0.162	±0.228	±0.147
Both arms restricted gait	±0.131	±0.241	±0.122
Maximum arm swing gait	±0.160	±0.248	±0.143

±standard deviation

This might be caused by the immobilization of the paralyzed upper limb which led to posture correction and liberation from abnormal immobilization of the non-paralyzed upper limb. Yavuzer et al reported that when an arm sling was worn in hemiplegic patients, the stance phase of the paralyzed side lower limb was prolonged and walking speed was gained[12]. In addition, Acar et al reported improvement of balance when arm slings were worn in hemiplegic patients[13]. Therefore, it is suggested that the way of swinging the upper limbs may change depending on paralysis severity of the lower limbs in clinical practice.

However, the limitation of this study is that the subjects were limited to those who can perform a 10m walking test without a walking aid because the swing of the non-paralyzed upper limb is necessary. Therefore, most of the severity of paralysis of the lower limb was mild. In addition, this study verified the immediate effect, while further study of the sustainability effect after a certain period of intervention might be needed. Furthermore, Corpus used in this study was reported in some academic conference, but there is no report on precision and reliability, hence further verification is needed.

Conclusion

Significant relationship between arm swing and walking ability in hemiplegia patients was not found in this study. However, when examined by paralysis severity, the velocity and the stride length increased in the order of both arms restricted, normal gait, maximum arm swing, single arm restricted. In addition, the usefulness of using arm slings was suggested.

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