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Analysis of Transportation Movements in Patients with Hemiparesis

Do-Yeong Kim[1], Tae-Hoon Kim[2]

[1]*Department of Health Science, Graduate School, Dongseo University, Bachelor, Korea*
chefdy@naver.com
[2] *Department of Occupational Therapy, Dongseo University, Associate Professor, Korea*
context@dongseo.ac.kr

Abstract

The objectives of this study were to compare unimanual, symmetrical and reciprocal movement of transportation. Nineteen participants with post-stroke hemiparesis were involved in this study. We used the Fitmeter accelerometer to measure the dependent variables: signal vector magnitude, peak acceleration and peak deceleration. With respect to the hand and arm, intensity of unimanual movement was higher than that of symmetrical movement, and reciprocal movement was greater than that of symmetrical movement. With regard to the trunk, intensity of unimanual movement was lower than that of symmetrical movement, and within bimanual movement, reciprocal movement was greater than that of symmetrical movement. In conclusion, reciprocal movement would facilitate upper extremity movement and decrease the compensatory movement of trunk more than would symmetrical movement.

Key Words: *Transportation, Unimanual, Symmetrical, Reciprocal.*

1. Introduction

Upper extremity tasks are divided into manipulation and transportation tasks according to the ratio of distal to proximal movement [1]. Manipulation task comprises finger and wrist movements more than elbow and shoulder movements and effective manipulation involves less movement of the elbow and shoulder than ineffective manipulation [2]. On the other hand, transportation task is generated by elbow and shoulder movements more than by finger and wrist movements, which means that effective transport involves more intense movement of the elbow and shoulder than does ineffective transport [2]. For example, normal adults use their elbow and shoulder while throwing a basketball with the dominant hand stronger and faster than with the non-dominant hand [3].

The movements of stroke patients differ from those of healthy individuals regarding trunks, shoulders, and arms [4], and the kinematics of unimanual transportation task differ from those of symmetrical or reciprocal tasks [5]. Besides, a few studies measured the upper part of the trunk during unimanual and symmetrical movement, although the trunk movement is proportional to the level of difficulty of the task. In other words, we should consider compensatory trunk movement [6].

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Corresponding Author: context@dongseo.ac.kr
Tel: +82-51-320-2718, Fax: +82-51-320-2721
Professor, Department of Occupational Therapy, Dongseo Unversity, Korea

This study compared the effects of unimanual and bimanual movement on the affected upper extremity and trunk movement in individuals with hemiparesis. The specific objectives of this study were to compare unimanual, symmetrial and reciprocal tasks of transportation.

2. Method

2.1 Participants

The mean age of 19 participants was 59.90 ± 16.25 years, and the mean time since stroke was 14.05 ± 12.40 months. Ten subjects were diagnosed with left hemiparesis, and nine subjects were diagnosed with right hemiparesis.

2.2 Experimental Apparatus and Equipment

2.2.1 Apparatus for Measuring Variables: Fitmeter Accelerometer

The Fitmeter, which records tri-axial acceleration, was developed by Fit Dot Life Corporation of Korea in 2010. The weight of the Fitmeter is 13.7 g, its size is 3.5 × 3.5 × 1.3 cm, and its range of measurement is 1/32 to 30 Hz [7]. We measured the raw data using the x, y, and z variables of acceleration, reformed as acceleration due to activity by removing gravitational acceleration, and calibrated signal vector magnitude (SVM) by summing-up the acceleration of the three axes [7].

Six markers were used and each marker attached to the right proximal phalanx of the thumb (first marker), right lateral epicondyle of the arm (second marker), xiphoid process of the trunk (third marker), left lateral epicondyle of the arm (fourth marker), and left proximal phalanx of the thumb (fifth marker)[8]. The sixth marker was used to measure the initiation and termination of movement.

2.2.2 Equipments for Performance Tasks

A chest (27 × 40 × 14 cm) was fixed 30 cm in front of the end of the table. The chest contained two drawers (16.5 × 11 × 4 cm) made of plastic material that had no handles. The initial location of the drawer was 10 cm in front of the end of the table. We used these drawers for the transportation tasks.

2.3. Experimental Procedure

2.3.1 Unimanual Transportation Using the Affected Hand

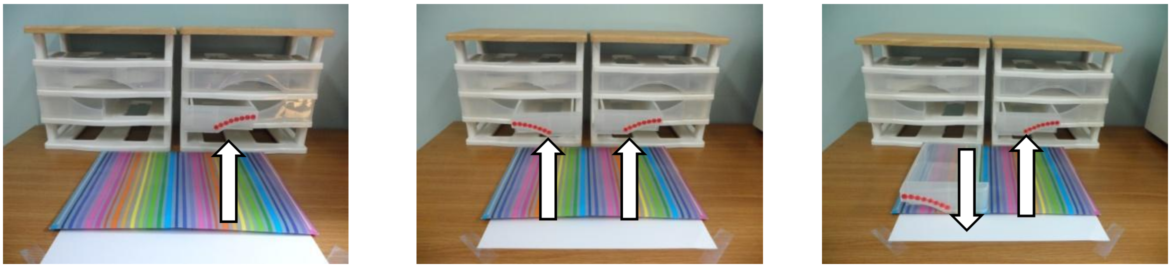
Shown as figure 1-a, participant reached forward 20 cm and pushed the drawer into the chest using only the affected hand.

2.3.2 Symmetrical Transportation Using Both Hands

Shown as figure 1-b, participant reached forward 20 cm and symmetrically pushed the drawer into the chest using both the affected hand and the unaffected hand.

2.3.3 Reciprocal Transportation Using Both Hands

Shown as figure 1-c, participant reached forward 20 cm and symmetrically pushed the drawer into the chest using the affected hand. At the same time, he or she opened the drawer and pulled it backward 20 cm using the unaffected hand.



(a) Unimanual (b) Symmetrical (c) Reciprocal

Figure 1. Transportation tasks

2.4. Dependent Variables

2.4.1 Signal vector magnitude (SVM)

We defined SVM as the sum of the squares of acceleration (A) of the x-, y-, and z-axes [7].

$$SVM = \sqrt{Ax^2 + Ay^2 + Az^2}$$

2.4.2 Peak Acceleration and Peak Deceleration

We used peak acceleration to measure movement velocity and peak deceleration to measure movement accuracy. We measured the x-, y-, and z-axis signals, but we used the signal of the z-axis as the representative value because it was the most sensitive axis among the three for measuring peak acceleration and peak deceleration of the body [9].

2.5. Data Analysis

Using two-way repeated analysis of variance with an α level of .05. Post hoc analyses were performed using a linear contrast test [10]. All analyses were calculated by using the software package SPSS 18.0 (SPSS, Inc., Chicago, IL).

3. Results

3.1. Signal vector magnitude (SVM)

For the hand, there were no significant differences in SVM among unimanual, symmetrical, and reciprocal transportation ($p > .05$). With respect to the arm, no significant differences in SVM were found among unimanual, symmetrical, and reciprocal transportation ($p > .05$). For the trunk, significant differences in SVM were found among unimanual, symmetrical, and reciprocal transportation ($p < .01$). On post hoc analysis, unimanual transportation was found to be significantly different from symmetrical transportation ($p < .01$), and symmetrical was significantly different from reciprocal transportation ($p < .05$). However, unimanual transportation was not significantly different from reciprocal transportation ($p > .05$) Table1 and figure 2 show it.

Table 1. Comparison of signal vector magnitude of the affected side during the transportation

	Unimanual	Symmetrical	Reciprocal	*F*	*p*
Hand	709.474±325.955	906.789±523.222	880.263±395.756	3.038	.074
Arm	371.368±132.067	459.579±241.370	450.421±176.763	2.754	.092
Trunk	116.789±67.720	208.789±123.851	132.421±101.344	8.606	$.003^{**}$

(N=19)($^{**}p < .01$)

3.2. Peak Acceleration

For the hand, there were no significant differences in peak z-axis acceleration among unimanual, symmetrical, and reciprocal transportation ($p > .05$). As for the arm, no significant differences in peak z-axis acceleration were found among unimanual, symmetrical, and reciprocal transportation ($p > .05$). With respect to the trunk, significant differences were found among unimanual, symmetrical, and reciprocal transportation ($p < .01$). The post hoc analysis revealed significant differences between unimanual and symmetrical transportation ($p < .01$) and between symmetrical and reciprocal transportation ($p < .01$), but unimanual transportation was not significantly different from reciprocal transportation ($p > .05$). Table2 and figure 3 show it.

Table 2. Comparison of peak z-axis acceleration of the affected side during the transportation

	Unimanual	Symmetrical	Reciprocal	*F*	*p*
Hand	11.947 ± 5.317	15.947 ± 11.428	15.053 ± 9.829	.990	.392
Arm	3.474 ± 2.716	4.368 ± 3.166	5.947 ± 4.196	2.974	.078
Trunk	2.737 ± 1.593	4.474 ± 2.220	3.000 ± 2.055	6.350	.009**

(N = 19) (**p < .01)

3.3. Peak Deceleration

With regard to the hand, no significant differences were found in peak z-axis deceleration among unimanual, symmetrical, and reciprocal transportation ($p > .05$). As for the arm, significant differences were found in peak z-axis deceleration among unimanual, symmetrical, and reciprocal transportation ($p < .05$). On post hoc analysis, there were significant differences between unimanual and symmetrical transportation ($p < .05$) and between symmetrical, and reciprocal transportation ($p < .05$). With respect to the trunk, significant differences were found among unimanual, symmetrical, and reciprocal transportation ($p < .01$). The post hoc analysis revealed significant differences between unimanual and symmetrical transportation ($p < .01$) and between symmetrical and reciprocal transportation ($p < .01$), but unimanual transportation was not significantly different from reciprocal transportation ($p > .05$) (Table 3, Figure 4).

Table 3. Comparison of peak z-axis deceleration of the affected side during the transportation

	Unimanual	Symmetrical	Reciprocal	*F*	*p*
Hand	-11.000±9.730	-15.211±7.983	-16.526±9.234	3.326	.060
Arm	-5.737±3.664	-6.632±3.370	-8.737±5.064	3.703	.046*
Trunk	-.421±.838	-1.473±.904	-.473±.513	9.393	.002**

(N = 19) (*p < .05; **p < .01)

4. Discussion

In our experiments, the intensity of trunk movement during symmetrical transportation was significantly greater than that during reciprocal transportation. Reciprocal transportation is used often, as in the arm swing of ambulation and in sport activities such as swimming, punching in boxing, and pitching in baseball [11]. The effect of the reciprocal arm swing, as seen in the freestyle and sidestroke in swimming, increases the intensity of arm movement and decreases the compensatory movement of the trunk [12]. Reciprocal arm movements also decrease trunk compensation in individuals with hemiparesis [13]. In addition, less compensatory trunk movement would produce faster, more intense arm movement [14].

For peak acceleration, there were no significant differences according to the type of movement. Peak acceleration, which is influenced by the activation of agonist muscles, reflects the velocity of movement [15, 16]. However, performing a task using both hands increases the attention demand and this decreases the velocity of movement than dose using one hand [17]. Therefore, we did not obtain a meaningful conclusion with respect to the velocity of movement between bimanual and unimanual movements.

As for the peak deceleration of reciprocal movement during transportation was greater than that of symmetrical movement. Peak deceleration, which is influenced by the activation of antagonist muscles, reflects the accuracy of the movement [18]. Coordination between agonists and antagonists is an essential strategy used by the motor system to facilitate accurate multi-joint arm movement [19]. The reciprocal inhibition of distal agonists and antagonists produces precise movement with minimal spatial error [20], and the co-activation of proximal agonists and antagonists yields proximal stability with minimal compensatory shoulder and trunk movement [6]. Many studies of limb control have shown that the co-activation of antagonist muscles around a joint minimizes the perturbing effects of external loads [21, 22]. Therefore, we suggest that reciprocal movement facilitates accurate movement more than symmetrical movement.

5. Conclusion

The reciprocal movement facilitated the movement of the affected upper extremity within the bimanual movement. For the trunk, reciprocal movement would decrease compensation by the trunk more than would symmetrical movement within the bimanual movement.

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