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Original Article

Sensitivity of the accelerometer as a measurement tool for upper extremity movement by stroke patients: a comparison with the action research arm test

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Abstract. [Purpose] This study investigated the sensitivity of an accelerometer in a comparison with the Action Research Arm Test (ARAT). [Subjects] Fifteen stroke patients participated in this study. [Methods] Subjects wore accelerometers on both wrists and performed the ARAT items. We then compared the data measured by the accelerometer with that of the ARAT. [Results] ARAT scores were higher on the non-affected side than the affected side, while the amount of upper extremity movement was higher on the affected side. The correlation coefficients for the two tools were not significantly different. [Conclusion] Our findings indicate that an accelerometer is a useful and sensitive instrument for clinically measuring the upper extremity activity of patients with stroke.
Key words: Accelerometer, Action Research Arm Test, Stroke

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INTRODUCTION

The accelerometer is a useful measurement tool for monitoring physical activity, especially the upper extremity activities of patients with stroke[1)]. Unlike previous assessment tools for upper-limb function after stroke, accelerometers can also assess level of performance of activities of daily living, as well as capacity (the ability to perform some action)[2)]. Thus, accelerometers allow objective measurement of upper-limb activity during daily living as well as in clinical practice[3)]. Several studies have explored the validity of accelerometry in recent years. A previous study found that accelerometry of daily arm activity was significantly related to the MAL-AOU scale, an upper-limb assessment tool which takes the form of a semistructured interview[4)]. An accelerometer was also used in a study assessing the reliability of Log-14 for upper limb measurement[5)]. However, subjects in these studies wore the accelerometer for more than one day, making it difficult to evaluate upper-limb movement of specific activities. The Action Research Arm Test (ARAT) is a tool that assesses the abilities of grasp, grip, pinch and performance of gross movements after stroke[6)]. It is a highly reliable and validated measurement tool for the evaluation of upper limb motor impairment[7)]. The ARAT is used to measure specific upper limb movements including fine and gross movements[8)], and a comparison between the accelerometer and ARAT would determine whether the accelerometer is a useful tool for monitoring specific upper limb activities. Accordingly, the purpose of this study was to investigate the sensitivity of an accelerometer in measuring upper extremity activities.

SUBJECTS AND METHODS

Fifteen subjects were recruited from rehabilitation hospitals in Won-Ju, Korea for this study. The inclusion criteria were: a diagnosis of stroke with hemiparesis, no severe deficits in cognitive function (Mini Mental State Examination (MMSE) score > 22) and the absence of orthopedic upper limb limitations. We obtained written informed consent using the form approved by the Yonsei University Wonju Institutional Review Board from all research subjects before beginning the study.

The accelerometer used in this study was a Fitmeter developed by Fit Dot Life Corporation of Korea in 2010. The Fitmeter is small (35 mm × 35 mm × 13 mm) and light (13.7 g) ; thus, it is easy and convenient to attach to a specific body part. The frequency of measurement and sensitivity of the Fitmeter are from 1/32 to 30 seconds and 2 to 8 G, respectively[9)]. For this study, the Fitmeter was set at 1/32 seconds and 2 G to measure slower activities and fine motor movements. The Fitmeter manager program presents data as tri-axial acceleration without gravity.

The ARAT assesses motor function of the upper limbs after stroke, as well as the amount of movement possible in stroke recovery stages. The ARAT uses a wooden box and different sizes of blocks and other objects. The ARAT consists of 19 test items including those that involve grasp (6), grip (4), pinch (6) and gross movement (3) actions. The highest possible ARAT score is 57, based on a four-point scale that rates the quality of movement over 60 seconds as follows: 0 = no movement, 1 = partial movement, 2 =

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movement performed slower than normal (5–60 seconds), 3 = movement performed normally (in less than 5 seconds). The test takes 5–15 minutes to complete, depending on the subject's symptoms[10]. The inter-rater and test-retest reliabilities for stroke patients were 0.99 and 0.98, respectively indicating high reliabilities[11].

The experiment was performed in a quiet room containing a desk and chair. Subjects wore accelerometers embedded within wrist bands on both wrists and performed the ARAT items. Subjects were required to place both arms on the desk before and after performing the ARAT in order to clarify the start and end point of the test. We then compared the data measured by the accelerometer with the ARAT.

We used descriptive statistics to analyze demographic characteristics. The Mann-Whitney test was used to compare median differences in ARAT and acceleration scores between the affected and non-affected sides. Spearman's rank correlation coefficient was calculated to test the significance of relationships between acceleration and ARAT variables.

RESULTS

Table 1 shows the demographic characteristics of the study subjects. The study included nine males and six females with a mean age of 67.3 ± 9.9 years. The right and left sides were affected by stroke almost equally. Average time since stroke was 3.1 ± 2.3 years. There was a significant difference in the median score between the affected and non-affected sides both the ARAT and accelerometer results. The ARAT scores were higher on the non-affected side ($p<0.05$), while upper limb activity was higher on the affected side ($p<0.05$) (Table 2). The correlation coefficient between ARAT and accelerometer results indicates that the results were not significantly correlated (Table 3).

DISCUSSION

Previous accelerometer studies primarily measured physical activity over several days[12]. In contrast, this study was performed in a clinical setting and measured and compared upper extremity movements of specific activities performed using the paretic and non-paretic hands. The accelerometer results indicated there is a significant difference between the affected and unaffected upper extremities, and this was confirmed by the ARAT. This shows that an accelerometer can be used to measure upper extremity movements.

ARAT and accelerometer measurements were not significantly different. This outcome was not consistent with previous studies comparing accelerometer recordings and the results of the Motor Activity Log and the Actual Amount of Use Test[1].

This study has several limitations. First, because we did not consider the timing of ARAT activities, there are data errors associated with the amount of upper limb movement as measured by the accelerometer. In addition, differences in quantitative and qualitative data of the accelerometer and ARAT affected the correlation coefficients. However, the results of this study indicate that the accelerometer is a sensitive tool for measuring upper limb activity. Future studies should use an accelerometer to measure specific activities in a clinical setting.

Table 1. Subject characteristics at baseline (n=15)

Characteristic	
Gender, M/F (total)	9/6, 15
Age (yrs)	67.3 ± 9.9
Affected side, L/R, (total)	7/8, 15
Time since stroke onset (y)	3.1 ± 2.3

Values expressed as mean ± SD or n.

Table 2. Median differences in ARAT and acceleration scores between the affected and non-affected sides

	Affected side	Non-affected side
ARAT	42.8 (11.1)*	57 (0)*
Accelerometer	74488.3 (51778.1)*	35963.1 (11240.5)*

Values are mean (SD), *$p<0.05$

Table 3. Correlation between ARAT and the accelerometer

	ARAT (affected side)
Accelerometer (affected side)	0.24
accelerometer (non-affected side)	0.91

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