J.Phys. Ther. Sci
23: 361-363, 2011

Evaluation of the Motor Recovery Process in Stroke Patients using a Laterality Index based on the Paretic and Non-Paretic Upper Limbs' Actigraphic Activity

Bumsuk Lee, OTR, PhD[1)], Junichi Kurihara, OTR, MS[2)], Keisuke Tokuda, OTR, BA[3)], Eiko Ogasawara, NS, MS[4)], Chikara Akiyoshi, OTR, MS[5)], Yasufumi Shiihara, MD, PhD [1)]

[1)] *Graduate School of Health Sciences, Gunma University: 3–39–15 Showamachi, Maebashi-shi, Gunma, 371-8514, Japan. TEL: +81 27-220-8993, FAX: +81 27-220-8999, E-mail: bslee@health.gunma-u.ac.jp*
[2)] *Division of Rehabilitation Service, Geriatrics Research Institute and Hospital*
[3)] *Division of Rehabilitation Medicine, Gunma University Hospital*
[4)] *School of Nursing, Faculty of Health Science, Gumma Paz College*
[5)] *Division of Rehabilitation Service, Central Gunma Neurosurgical Hospital*

Abstract. [Purpose] The aim of this study was to monitor the motor recovery process of stroke patients using a laterality index between the paretic and non-paretic upper limb actigraphic activities.
[Subjects and Methods] Sixteen stroke patients wore an Actiwatch® accelerometer on both wrists for 24 hours. The motor activity was recorded at four different time points: approximately 15 days, 33 days, 61 days and 91 days after the onset of stroke. [Results] An increase in motor activity was found on both sides during the course of the recovery process. The laterality index also increased, suggesting an improvement in the paretic side. In patients who showed little improvement on the paretic side, the activity increased on both sides, but the laterality index remained almost constant. Moreover, a significant positive correlation was found between the laterality index and the Brunnstrom stage (arm; rs=0.83, hand; rs =0.82). [Conclusions] Our results suggest that the laterality index of actigraphic activity is useful for assessing real improvement of the paretic side.
Key words: Accelerometer, Laterality index, Motor recovery

(This article was submitted Oct. 21, 2010, and was accepted Nov. 16, 2010)

INTRODUCTION

Actigraphy is an objective tool used to evaluate motor activity during free-living activities[1)]. Some studies have reported it is useful for the monitoring motor activity of stroke patients. The advantage of actigraphy is that it can show the profile of motor activity over long periods of time in a patient's everyday life[2–4)].

It is difficult to evaluate the recovery process in stroke patients. Increasing motor activity on the paretic side does not always indicate recovery because behavioral activity varies from day to day. To solve this problem, we introduced a laterality index between the paretic and non-paretic side, which has been used to assess handedness[5,6)].

Using this laterality index, we followed the recovery process after stroke for three months. We also examined the correlation between the laterality index and Brunnstrom stage, which is the standard scale for evaluating the degree of paresis.

SUBJECTS AND METHODS

Subjects

Sixteen stroke patients (12 males and 4 females, 64.5 ± 13.2 years) participated in this study. They were diagnosed as having stroke by a neurologist, based on neuroimaging. Seven patients had lesions in the left hemisphere and 9 patients in the right hemisphere. All patients were admitted in the acute phase and underwent rehabilitation programs. The patients and their families gave their informed consent. The study was approved by the ethics committee of Gunma University.

Methods

The upper limb activity was actigraphically recorded four times over about three months after the onset of stroke: 14.7 ± 4.8 days after the stroke ("onset month"), 33.3 ± 3.5 days later ("1 month after"), 61.3 ± 3.7 days later ("2 months after") and 91.4 ± 2.7 days later ("3 months after"). The activities from Actiwatchs® (Mini-Mitter Co.)

Table 1. Total activity counts and Laterality index at four different time points. The laterality index was compared with that obtained at the previous time point (mean ± SD; n=16)

	Onset month	1 month after	2 months after	3 months after
Activity Counts (10^4counts / day)				
Non paretic arm	20.5 ± 8.2	27.1 ± 10.4	28.3 ± 12.1	34.5 ± 16.0
Paretic arm	8.0 ± 5.6	10.8 ± 6.2	14.1 ± 9.1	19.4 ± 13.2
Laterality Index	–0.47 ± 0.27	–0.44 ± 0.27*	–0.35 ± 0.31*	–0.32 ± 0.29

*Significant Laterality Index difference between 1 and 2 months after stroke ($p<0.01$)

Table 2. The progress of a patient who showed little improvement on the paretic side

	Onset month	1 month after	2 months after	3 months after
Activity Counts (10^4counts / day)				
Non paretic arm	24.3	32.9	33.8	55.7
Paretic arm	17.0	20.3	24.7	40.4
Laterality Index	–0.18	–0.23	–0.15	–0.16

accelerometers on both wrists were recorded over 24 hours. In the Actiwatchs®, an internal acceleration sensor records movements and accumulates them over a 15 second interval. Additionally, motor recovery was assessed using the Brunnstrom stage.

The laterality index was calculated using the total activity counts from the paretic and non-paretic sides (paretic – non-paretic) / (paretic + non-paretic). The laterality index ranges from -1 to 1, depending on whether the patients dominantly used the non-paretic or paretic side. If there is no activity difference, the score is zero.

The laterality index and total activity counts over 24 hours were compared with those obtained at the previous time point (onset month vs 1 month after, 1 month after vs 2 months after and 2 months after vs 3 months after). Parametric tests using ANOVA and the paired t-test with Bonferroni's correction were used for statistical analysis. p values < 0.05 were considered significant. Spearman's rank correlation coefficients were calculated between the actigraphic measurements (total activity counts for the paretic side, non-paretic side and laterality index) and Brunnstrom stage. For the analyses, the statistical software SPSS 17.0J for Windows TM (SPSS Japan Inc.) was used.

RESULTS

Total activity counts for the paretic ($F=13.8$; $p<0.001$) and non-paretic sides ($F=10.8$; $p<0.001$) showed significant increases along with the course of recovery (n=16). The laterality index also showed a significant increase ($F=11.8$, $p<0.001$). Total activity counts were higher than those at the previous time point (paired t-test with Bonferroni's correction, $p < 0.05$), except between 1 and 2 months after on the non-paretic side. The laterality index increased only from 1 to 2 months after (paired t-test with Bonferroni's correction, $p<0.01$) (Table 1).

In patients who showed little improvement on the paretic side, the activity increased on both sides, but the laterality index remained almost constant (Table 2).

Table 3. Spearman's rank correlation coefficients (rs) between the actigraphic measurements and Brunnstrom stage at each recording time point (n=64)

		Brunnstrom stage score	
		Arm	Hand
Activity Counts	Non paretic arm	–0.10	–0.13
	Paretic arm	0.71*	0.68*
Laterality Index		0.83*	0.82*

*$p<0.01$

Table 3 shows the Spearman's rank correlation coefficients between the laterality index and Brunnstrom stage score at each recording time point (n=64). A significant correlation was found between the total activity counts on the paretic side and Brunnstrom stage (arm; $rs=0.71$, hand; $rs=0.68$, $p<0.01$). There was a positive correlation between the laterality index and Brunnstrom stage (arm; $rs=0.83$, hand; $rs=0.82$, $p<0.01$). However, we did not observe any significant correlation between the total activity counts on the non-paretic side and Brunnstrom stage score (arm; $rs=-0.10$, hand; $rs=-0.13$).

DISCUSSION

In this study, we used an actigraphic laterality index to assess real improvement on the paretic side in stroke patients because it is more useful to measure the activity ratio of the paretic and non-paretic sides than the activity count of the paretic side alone. Indeed, in patients who showed little improvement on the paretic side, the activity

increased on both sides, but the laterality index remained almost constant (see Table 2).

We think that the activity counts on the paretic side include two components: those influenced by whole body movement and those influenced by real movement of the paretic side. Activity counts due to whole body movement for the most part originate from activities of daily living, which increase in the course of the rehabilitation process. For instance, the patient's everyday life in hospital is somewhat limited. When the patients return to the home environment and to a normal daily routine, their whole body movement shows an increase. However, these influences extend to both the paretic and non-paretic sides. Rand et al. [3] reported an excellent correlation between the paretic and non-paretic hips for activity counts in stroke patients. Therefore, it is possible to cancel these influences by using the laterality index gained from the activity of both sides.

Based on this study, we conclude that the laterality index could be clinically useful. It could serve as an objective index for assessing real improvement of the paretic side of stroke patients.

REFERENCES

1) McClain JJ, Sisson SB, Tudor-Locke C: Actigraph accelerometer interinstrument reliability during free-living in adults. Med Sci Sports Exerc, 2007, 39: 1509–1514.
2) Page SJ, Sisto SA, Levine P: Modified constraint-induced therapy in chronic stroke. Am J Phys Med Rehabil, 2002, 81: 870–875.
3) Rand D, Eng JJ, Tang PF, et al.: How active are people with stroke?: use of accelerometers to assess physical activity. Stroke, 2009, 40: 163–168.
4) Reiterer V, Sauter C, Klosch G, et al.: Actigraphy–a useful tool for motor activity monitoring in stroke patients. Eur Neurol, 2008, 60: 285–291.
5) Lehnkering H, Strauss A, Wegner B, et al.: Actigraphic investigations on the activity-rest behavior of right- and left-handed students. Chronobiol Int, 2006, 23: 593–605.
6) Nagels G, Marion P, Pickut BA, et al.: Actigraphic evaluation of handedness. Electroencephalogr Clin Neurophysiol, 1996, 101: 226–232.