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Abstract

The purpose of this study was to clarify whether a gait analysis using an accelerometer could estimate gait independence. Eighty-six stroke patients and 21 healthy control subjects participated in this study. Stroke patients were identified as dependent or independent based on their gait ability. The acceleration of the trunk and bilateral thigh was measured using three wireless sensors during walking. The root mean square, gait regularity, and symmetry were calculated from the acceleration to estimate gait quality. ANCOVA showed that gait regularity of the trunk and bilateral thigh were significant lowest in the dependent group, regardless of gait velocity. A logistic regression analysis showed that the regularity and root mean square of the anteroposterior acceleration of the unaffected thigh were the key factors for estimating gait independence. This study suggests that an acceleration-based gait analysis facilities gait independence estimation, and is a useful tool during the rehabilitation of stroke patients.

Keywords: accelerometer, gait regularity, gait quality, gait independence

Estimation of gait independence using a tri-axial accelerometer in stroke patient

Strokes are a common occurrence in older people, 16 million people worldwide underwent primary stroke in 2005 and 5.7 million of them died. The number of primary stroke patients is expected to reach 23 million by 2030 (Strong, Mathers, & Bonita, 2007). Strokes frequently cause serious impairments, such as paralysis and abnormal muscle tone, that result in limitation to daily activities. Furthermore, many stroke survivors have ambulatory difficulty and their gait can be characterized by asymmetry of the lower extremity motion (Lauzière, Miéville, Betschart, Aissaoui, & Nadeau, 2015; Patterson, Gage, Brooks, Black, & McIlroy, 2010), increased disturbance of the trunk (Kao, Dingwell, Higginson, & Binder-Macleod, 2014), decreased velocity (Taylor-Piliae, Latt, Hepworth, & Coull, 2012), and poor endurance (Combs et al., 2013; Mudge & Stott, 2009). This loss of independent gait reduces **activities** of daily living and quality of life; therefore, regaining independent gait is an important goal in the rehabilitation of stroke patients. An objective assessment of gait quality is essential for the effective improvement of gait function.

Assessment of the gait function in stroke patients is usually performed using a three-dimensional motion analysis system and a force plate in the laboratory. However, these methods **are not used more frequently** in clinical practice because of complications in measurement and data processing **(Krause et al., 2015)**. On the other hand, accelerometers are becoming increasingly popular for assessing human movement and gait (Gonzales, Shephard, & Dubey, 2015). Their small size and affordability combined with improved accuracy and data storage capabilities make them highly effective tools for research and clinical assessments. Several studies have suggested that an accelerometer can be used to analyze spatiotemporal gait measurements **in healthy adults,** and that it is a useful method for objective and reliable assessments (Moe-Nilssen & Helbostad, 2004; Senden, Grimm, Heyligers, Savelberg, & Meijer, 2009; Terrier & Reynard, 2015; Zakaria, Kuwae, Tamura, Minato, & Kanaya, 2015).

In a gait analysis using **an tri-axial accelerometer** attached to the lumbar region, the disturbance of the trunk during walking was estimated by the root mean square (RMS; Sekine et al., 2013), and the gait regularity and symmetry were estimated by the autocorrelation methods (Kobsar, Olson, Paranjape, Hadjistavropoulos, & Barden, 2014). A previous study analyzed the effect of age on acceleration of the trunk during walking and found that older adults had a lower gait regularity than did young adults (Menz, 2003). Matsumoto et al. (2015) reported that regularity in vertical acceleration during walking is a significant predictor of the fall in patients with a fracture.

A few studies that analyzed gait quality by an accelerometer attached to the lumbar region stated that an accelerometer-based gait analysis would be useful during stroke rehabilitation. Mizuike, Ohgi, & Morita (2009) reported that stroke patients with a serious functional loss in the lower extremity showed a smaller vertical RMS, larger mediolateral RMS, and lower gait regularity. Hodt-Billington, Helbostad, & Moe-Nilssen (2008) indicated asymmetry in the gait of stroke patients was higher than that of healthy older people. Stroke patients often walk with an abnormal lower extremity motion, with hip circumduction and leg stiffness on the affected side (De Quervain, Simon, Leurgans, Pease, & McAllister, 1996; Tyrell, Roos, Rudolph, & Reisman, 2011) **coupled with**, rapid swing and long stance phase on the unaffected side (Olney, Griffin, & McBride, 1994; Tyrell et al., 2011). Therefore, acceleration of the lower extremity could help in an objective assessment of gait quality. So far, no studies have reported on the relationship between an acceleration of trunk or lower extremity and gait independence in stroke patients. We therefore aimed to clarify whether a gait analysis using an accelerometer could estimate gait independence **in stroke patients.** We expected that the evaluation of gait quality from RMS, gait regularity, and symmetry of the acceleration in the trunk and bilateral thigh could estimate whether a stroke patient could walk independently or not. **We consider that accelerometers could estimate gait quality relating to gait independence more objectively and in** greater detail than simple visual observation. Such additional information would be extremely beneficial for gait training in stroke rehabilitation.

Methods

Subjects

Eighty-six stroke patients (age, 65.6 ± 13.3 years) and 21 healthy older control subjects (age, 63.3 ± 4.3 years) participated in this study (Table 1). Stroke patients were recruited from inpatient and outpatient departments under the rehabilitation program at xxxxx. In stroke patients, gait dysfunction is mainly caused by lower extremity dysfunction. Moderate motor impairment makes it difficult to decide whether a patient can walk independently or not, thus, we focused on stroke patients with moderate motor dysfunction. The degree of motor dysfunction was evaluated by Brunnstrom recovery stage, which assesses the deviation from abnormal synergy (Brunnstrom, 1966). Brunnstrom recovery stage classifies the degree of motor function in a range from I to VI, with stage VI indicating mild paralysis and stage IV-V indicating moderate dysfunction (Kautz, Patten, & Neptune, 2006; Turns, Neptune, & Kautz, 2007). Meanwhile, performance during activity daily living is usually evaluated by FIM, which classifies performance level into a score ranging from 1 to 7 (Granger et al., 1986). In the FIM walk score, a score of 1-4 indicates walking with helper, score 5 indicates walking with a

supervisor, and a score of 6-7 indicates walking without a helper. The current study enrolled stroke patients with a Brunnstrome recovery stage of IV-V and an FIM walk score of 5-7. Healthy control subjects were recruited from volunteers living in the community so that their average age was similar to that of the stroke patients. The inclusion criteria for stroke patients were as follow (1) diagnosis of a cerebral hemorrhage or a cerebral infraction, (2) first unilateral stroke, **(3) the ability to understand and follow the instructions given by the researcher.** The exclusion criteria **for both groups** were presence of orthopedic disease, severe cardiopulmonary disease, or cognitive dysfunction **that could interfere with gait.** Estimating gait independence using the FIM walk score resulted in stroke patients being assigned to the dependent group (FIM score 5, n = 43) or the independent group (FIM score 6 or 7, n = 43) based on their gait ability. Prior to the investigation, all participants provided written informed consent for participation in the study. This study was approved by the Ethics Committee of xxxxx (Number 93).

Instruments

Three wireless sensor units consisting of three-axial acceleration sensors (MMA7260Q, Freescale Semiconductor, TX, USA), an amplification circuit, a filter circuit and a built-in microcomputer (PIC16F88, Microchip, AZ, USA) **were** used to measure anteriorposterior (AP), mediolateral (ML) and vertical (VT) accelerations during walking. The sensor size and weight were 40 × 55 × 20 mm and 37 g including a battery, respectively. The reliability of the sensor was tested sufficiently prior to this examination, and it was also used in the other report (Sekine et al., 2013; Zakaria et al., 2015). The sensor unit output digital data to a PC through a Bluetooth transmitter (ZEAL-S01, ADC Technology, CA, USA) after a 10-bit A/D conversion for later analysis. The wireless sensor units were attached to the lumber region around the L3-L4 vertebrae and bilateral thigh, 7 cm above the lateral epicondyle, using an elastic belt **(Henriksen, Lund, Moe-Nilssen, Bliddal, & Danneskiod-Samsøe, 2004; Higashi, Y., Yamakoshi, K., Fujimoto, T., Kobsar, Olson, Paranjape, Hadjistavropoulos, & Barden, 2008; Sekine, M., & Tamura, T, 2013)**. The sampling frequency was 100 Hz, and the response frequency was DC-30 Hz. The output data were filtered by a third order Butterworth bandpass filter with a cut-off frequency of 0.2 Hz and 30 Hz. Initial contact was determined by the peak of the trunk AP acceleration (Combs et al., 2013; Senden et al., 2009; Zijlstra & Hof, 2003), and the stance leg side was identified from the thigh AP acceleration. We **assessed** the output reliability of the initial contact lumbar and thigh accelerations using a synchronized video camera (GZ-HM570; JVC Kenwood Co., Tokyo, Japan) in advance.

Measurement

Participants walked 16 m along a straight walkway with comfortable velocity using walking aids that they used every day. Gait velocity was calculated from the time taken to walk the middle 10 m. We assessed the disturbance, gait symmetry, and regularity from trunk and thigh accelerations in the middle of five walking cycles, initiated by foot contact in either the affected or left leg. Gait fluctuation was estimated by RMS. In accordance with previous study (Mizuike et al., 2009), gait regularity was estimated from acceleration using an autocorrelation function at the average stride time lag, which was closer to one when the similarity of consecutive strides was high, using the Pearson product-moment correlation coefficient (Tura et al., 2010). Similarly, gait symmetry was assessed by the autocorrelation function of trunk acceleration at the average step time lag and the cross-correlation function between the bilateral thighs without a time lag. Both coefficients were close to one when similarity of the contralateral step was high. Data were processed using Scilab 5.4.1 (Scilab Enterprises, Versailles, France).

Statistical analysis

To examine the ability to distinguish gait independence using acceleration during walking, we analyzed the differences between the dependent, independent and control groups. The Brunnstrom stage and disease duration were tested by chi-squared test or unpaired t-test. The age, velocity, and gait quality were tested using a one-way analysis of variance (ANOVA). In addition, analysis of covariance (ANCOVA) was used to compare differences among the groups (dependent vs. independent vs. control) excluding the effect of gait velocity, because acceleration during walking is affected by gait velocity (Henriksen, Lund, Moe-Nilssen, Bliddal, & Danneskiod-Samsøe, 2004; Kavanagh, 2009). A Bonferroni post hoc test was used when necessary. **Meanwhile, η^2 was calculated to estimate the effect size in ANOVA and ANCOVA. Effect size was classified into small ($\eta^2 = 0.01$), medium ($\eta^2 = 0.06$), and large ($\eta^2 > 0.14$), according to a previous study (Cohen, 1998).**

For the parameter showed a $P < 0.25$ in a post hoc test, a multiple logistic analysis was used to examine the factor related to gait independence. Prior to a logistic analysis, multicollinearity was tested using the Pearson correlation coefficient among the acceleration indicators. **To avoid multicollinearity of categorical variables,** one of the two indicators that showed a high correlation ($r > 0.8$) was excluded from later analyses. All statistical analyses were performed using IBM SPSS Statistics 21.0. For all analyses, the level of significance was set at $P < 0.05$.

Results

Stroke patients walked more slowly than the control group, and the dependent group walked significantly more slowly than the independent group (Table 1). Similarly, RMS of the trunk and thigh were smaller in stroke patients, especially the dependent group, compared with the control group (Table 2).

Gait regularity estimated by an autocorrelation function was significantly lower in stroke patients than in the control group for all directions of trunk and bilateral thigh accelerations (Table 3A). The dependent group walked with decreased regularity in all accelerations, except for the AP and ML directions in the affected thigh. Similarly, the symmetry was lower in stroke patients than in the control group (Table 3B). The gait of the dependent group had a high asymmetry of the trunk for AP and VT directions, and of the thigh for VT direction.

An ANCOVA was performed on all indicators, except RMS of the trunk for AP and VT, the regularity of the trunk for AP and VT, the regularity of the affected thigh for AP, and symmetry of the thigh for AP, which did not show parallelism among the three groups. The ANCOVA revealed that the regularity of the trunk in all directions, the affected thigh in VT and unaffected thigh in AP and VT were lowest in the dependent group regardless of gait velocity (Table 4). **Even though gait velocity was adjusted, the results of comparison among groups had a medium or large effect size.** RMS, excluding the ML in trunk acceleration, showed no significant intergroup differences demonstrating that the indicator differences among the three groups were dependent on gait velocity.

The logistic regression analysis extracted RMS and regularity in AP acceleration of the unaffected thigh as factors for estimating gait independency. The correct classification rate of this model was 86.0% (Table 5).

Discussion

In this study, we examined the ability to estimate the gait independence using three-axial accelerometer attached to the trunk and bilateral thigh in stroke patients. Our results indicated that stroke patients, especially those in the dependent group, had a reduced RMS and walked with lower regularity and symmetry compared to the control group. The differences in gait regularity among the three groups were not dependent on gait velocity. RMS and regularity of the unaffected thigh AP acceleration were identified as key factors for estimating the degree of gait independence. These results were consistent with our hypothesis.

Stroke patients walked more slowly than the control group, and the dependent group walked significantly more slowly than independent group; these results were consistent with a previous report (Meijer et al., 2011). A study has suggested the importance of gait velocity to assess the gait ability in stroke patients (Schmid et al., 2007), and gait velocity has a large influence on acceleration (Henriksen et al., 2004). Therefore, we examined acceleration during walking with and without the effects of gait velocity.

RMS of acceleration of the trunk and both thighs was smallest in the dependent group. When the gait velocity was controlled, there was no difference in RMS of the thigh among the three groups, indicating that the RMS difference was mainly due to differences in gait velocity. RMS of the trunk ML acceleration adjusted for gait velocity was a slightly higher in stroke patients than in the control group, consistent with a previous study (Mizuike et al., 2009). However, significant difference was not observed in intergroup comparisons.

Gait regularity in all directions of the trunk and unaffected thigh and in the VT direction of the affected thigh was decreased in the dependent group compared with the independent and control groups, consistent with previous studies (Meijer et al., 2011; Mizuike et al., 2009). In comparisons excluding the effect of gait velocity, gait symmetry, calculated from an acceleration in AP and VT directions of the trunk and in the VT direction of the thigh, was decreased in the dependent group compared with the independent and control groups. Kobsar et al. (2014) reported that the regularity and symmetry during walking was decreased with age in healthy adults, reflecting the decline in control and coordination of the locomotor system. Therefore, the decreased gait regularity observed in the independent group was related to the severity of the lower limb motor function and impairment of postural control during walking.

Gait asymmetry was increased in stroke patients, similar to previous studies (Hodt-Billington et al., 2008; Meijer et al., 2011). In this study, the dependent group showed a higher asymmetry than the independent and control groups. This asymmetry during walking has been identified as a characteristic of stroke patients in many previous studies, which reported the longer swing time, shorter step length, reduced ground reaction force and joint moment in the affected lower extremity compared with the unaffected side (Lauzière et al., 2015; Patterson et al., 2010). The asymmetric gait in stroke patients was mainly due to functional impairments in the unilateral extremity, resulting in a large lateral displacement in the unaffected side of the center of mass (Balasubramanian, Neptune, & Kautz, 2010). Therefore, a decreased gait symmetry interferes with efficient gait performance (Mudge & Stott, 2009), and Awad et al. (2015) further reported on the significant relationship between gait symmetry and the energy cost during walking in stroke patients.

Regularity in the AP direction and RMS of the unaffected thigh acceleration were extracted as factors that could estimate gait independence. The amplitude of thigh acceleration increased during the initial contact to the loading response and pre-swing to the initial swing phase. An increased RMS and regularity of the unaffected thigh would reflect the steady swing of the unaffected leg with sufficient support and postural control by the affected lower extremity, resulting in an increased gait velocity. Although gait asymmetry is an important characteristic of the gait of stroke patients, gait regularity was a key factor for classification of gait independence. Mizuike et al. (2009) reported that gait regularity related to lower limb motor function in stroke patients. Kim & Eng (2004) reported that stroke patients who could walk fast did not necessarily exhibit gait patterns similar to those reported for healthy adults. For example, a compensatory asymmetrical pattern, including a hip abductor pattern during the swing, is beneficial for increasing gait velocity. These suggest the importance of the gait regularity rather than the gait symmetry for estimating gait independence. Further, using a cane might have contributed to the gait asymmetry observed in this study. Previous studies have reported that the use of a cane increased the lateral displacement of the trunk, and the step length in the affected side not in the unaffected side, decreasing gait symmetry (Kuan, Tsou, & Su, 1999; Tyson, 1999).

Therefore, therapists have to evaluate gait promptly so that stroke patients can relearn gait regularity in addition to gait asymmetry. It is difficult to assess gait regularity and the steady swing of the unaffected lower extremity by visual observation of walking or by measuring the gait velocity. An acceleration-based gait analysis would be a useful tool **for gait training** in stroke rehabilitation because it could easily evaluate gait quality and gait independence.

There are **several** limitations to this study. Since the design was cross-sectional, we did not analyze the longitudinal change of acceleration during recovery of the gait function. The use of a cane affected the gait symmetry, resulting in its minor contribution to gait independence. **Although this study showed a medium or large effect size when acceleration was compared, the heterogeneous nature among groups and small sample sizes may have affected the current results.** Future investigations that address these issues are required for exact estimate of gait independence using an accelerometer.

In conclusion, we intend to clarify the ability to estimate gait independence using an accelerometer attached to the trunk and bilateral thigh of stroke patients. Our results showed that RMS and regularity of the unaffected thigh acceleration could estimate gait independence in stroke patients with a dependent or independent gait. The accelerometer was considered to be a meaningful tool to assess gait quality during the rehabilitation of stroke patients. **Furthermore, therapists should assess regularity in the swing of the unaffected leg, and should aim to improve function in the affected lower extremity, to create sufficient support and postural control, during stroke rehabilitation.**

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Conflict of Interest

None of the authors have any conflicts of interest associated with this study.

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Table 1

Demographics and clinical characteristics of the subjects

	Stroke patients		Control	F	P
	Dependent	Independent			
Number	43	43	21		
Sex (male/female)	26 / 17	31 / 12	8 / 13		
Age (years)	69 ± 10*	61 ± 14	63 ± 3	4.5	0.004
Gait velocity (m/s)	0.33 ± 0.12**††	0.68 ± 0.26††	1.35 ± 0.17	184.7	< 0.001
From onset (months)	2.9 ± 3.6*	7.0 ± 10.1			
Brunnstrom Stage (IV/V)	23 / 20	23 / 20			
Affected side (right/left)	28 / 15	18/25			
FIM walk (5/6/7)	43 / 0 / 0	0 / 42 / 1			
Using of single point cane	43	40			
Using of ankle-foot orthosis	27	30			

Note. FIM = Functional Instrument Measurement. *P < 0.05, significant difference vs. Independent. **P < 0.01, significant difference vs. Independent. †P < 0.05, significant difference vs. Control. ††P < 0.01, significant difference vs. Control.

ESTIMATION OF GAIT USING ACCELEROMETER

Table 2

Root mean square (g) during walking among the three groups

	Dependent	Independent	Control	F	η^2	P
Trunk						
Anteroposterior	0.08 ± 0.02**††	0.12 ± 0.03††	0.21 ± 0.05	87.3	**0.63**	< 0.001
Mediolateral	0.08 ± 0.02**††	0.12 ± 0.04††	0.16 ± 0.03	42.4	**0.45**	< 0.001
Vertical	0.08 ± 0.03**††	0.14 ± 0.05††	0.28 ± 0.06	118.1	**0.69**	< 0.001
Affected thigh						
Anteroposterior	0.26 ± 0.11**††	0.43 ± 0.17††	0.75 ± 0.15	77.5	**0.60**	< 0.001
Mediolateral	0.12 ± 0.04**††	0.18 ± 0.07††	0.27 ± 0.06	45.3	**0.47**	< 0.001
Vertical	0.10 ± 0.04**††	0.21 ± 0.10††	0.44 ± 0.10	111.4	**0.68**	< 0.001
Unaffected thigh						
Anteroposterior	0.26 ± 0.07**††	0.44 ± 0.16††	0.75 ± 0.15	97.4	**0.65**	< 0.001
Mediolateral	0.12 ± 0.03**††	0.18 ± 0.06††	0.27 ± 0.06	51.0	**0.50**	< 0.001
Vertical	0.12 ± 0.04**††	0.22 ± 0.09††	0.44 ± 0.10	107.1	**0.67**	< 0.001

Note. Values are presented as mean ± standard deviation. **P < 0.01, significant difference vs. Independent. ††P < 0.01, significant difference vs. Control.

Table 3

Gait regularity and gait symmetry among the three groups

	Dependent	Independent	Control	F	η^2	P
A. Gait regularity						
Trunk						
Anteroposterior	0.65 ± 0.13**††	0.75 ± 0.11††	0.88 ± 0.07	29.0	**0.36**	< 0.001
Mediolateral	0.46 ± 0.14**††	0.56 ± 0.15††	0.75 ± 0.10	29.2	**0.36**	< 0.001
Vertical	0.38 ± 0.14**††	0.62 ± 0.16††	0.87 ± 0.07	86.9	**0.63**	< 0.001
Affected thigh						
Anteroposterior	0.44 ± 0.13††	0.48 ± 0.15††	0.82 ± 0.09	62.5	**0.55**	< 0.001
Mediolateral	0.44 ± 0.13††	0.49 ± 0.12††	0.75 ± 0.12	40.9	**0.44**	< 0.001
Vertical	0.41 ± 0.12**††	0.56 ± 0.14††	0.81 ± 0.09	71.4	**0.58**	< 0.001
Unaffected thigh						
Anteroposterior	0.43 ± 0.13**††	0.62 ± 0.14††	0.82 ± 0.09	63.8	**0.55**	< 0.001
Mediolateral	0.42 ± 0.13**††	0.53 ± 0.13††	0.75 ± 0.12	41.5	**0.44**	< 0.001
Vertical	0.43 ± 0.12**††	0.61 ± 0.13††	0.81 ± 0.09	67.3	**0.56**	< 0.001
B. Gait symmetry						
Trunk						
Anteroposterior	-0.11 ± 0.31**††	0.17 ± 0.39††	0.86 ± 0.06	65.6	**0.56**	< 0.001
Mediolateral	-0.25 ± 0.21††	-0.23 ± 0.21††	-0.70 ± 0.11	44.9	**0.46**	< 0.001
Vertical	0.05 ± 0.14**††	0.23 ± 0.30††	0.84 ± 0.06	93.9	**0.64**	< 0.001
Thigh						
Anteroposterior	0.26 ± 0.11††	0.23 ± 0.09††	0.48 ± 0.08	43.1	**0.45**	< 0.001
Mediolateral	0.28 ± 0.13	0.22 ± 0.09	0.25 ± 0.10	2.6	**0.05**	0.078
Vertical	0.22 ± 0.08*††	0.29 ± 0.13††	0.47 ± 0.09	37.6	**0.42**	< 0.001

Note. Gait regularity was estimated by an autocorrelation function. Gait symmetry was estimated by an autocorrelation function or cross correlation function. Values are presented as mean ± standard deviation. *P < 0.05, significant difference vs. Independent. **P < 0.01, significant difference vs. Independent. ††P < 0.01, significant difference vs. Control.

ESTIMATION OF GAIT USING ACCELEROMETER

Table 4

Adjusted means and standard deviations that showed a significant difference between the independent group and the dependent group by ANCOVA

	Dependent	Independent	Control	F	η^2	P
RMS of trunk (*g*)						
Mediolateral	0.11 ± 0.04	0.13 ± 0.03	0.10 ± 0.05	4.6	**0.08**	0.012
Regularity of trunk						
Anteroposterior	0.67 ± 0.17*†	0.75 ± 0.11	0.85 ± 0.21	4.6	**0.08**	0.013
Mediolateral	0.44 ± 0.21**††	0.57 ± 0.14††	0.81 ± 0.26	10.5	**0.17**	< 0.001
Vertical	0.46 ± 0.20**††	0.62 ± 0.14	0.71 ± 0.25	8.7	**0.14**	< 0.001
Regularity of affected thigh						
Mediolateral	0.46 ± 0.19††	0.49 ± 0.13††	0.72 ± 0.24	8.7	**0.14**	< 0.001
Vertical	0.47 ± 0.18*††	0.56 ± 0.12†	0.69 ± 0.22	5.4	**0.10**	0.006
Regularity of unaffected thigh						
Anteroposterior	0.49 ± 0.20**††	0.63 ± 0.13	0.73 ± 0.24	7.7	**0.13**	0.001
Vertical	0.49 ± 0.18**††	0.62 ± 0.12	0.71 ± 0.22	7.5	**0.13**	0.001
Symmetry of trunk						
Mediolateral	-0.17 ± 0.29††	-0.24 ± 0.20††	-0.86 ± 0.35	29.4	**0.36**	< 0.001

Note. Gait regularity was estimated by an autocorrelation function among the three groups.Values are presented as mean ± standard deviation. *P < 0.05, significant difference vs. Independent. **P < 0.01, significant difference vs. Independent. †P < 0.05, significant difference vs. Control. ††P < 0.05, significant difference vs. Control.

Table 5

Result of logistic regression analysis

	Logistic regression coefficient	Odds ratio (95% CI)	P
Unaffected thigh anteroposterior regularity	0.861	2.366 (1.440 – 3.887)	0.001
Unaffected thigh anteroposterior RMS	0.160	1.173 (1.076 - 1.280)	< 0.001
Intercept	-9.673		< 0.001

Note. CI = Confidence Interval. The correct classification rate of this model was 86.0%. The odds ratio was calculated on the basis of increments of 0.1 in regularity and 0.01 *g* in RMS, respectively.