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Original Article

Relationship between movement asymmetry and sit-to-stand/stand-to-sit duration in patients with hemiplegia

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ABSTRACT
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Objective: To elucidate the relationship between side-to-side asymmetry and sit-to-stand and stand-to-sit duration in patients with right or left hemiplegia by three-dimensional motion analysis of the two movements.
Methods: Forty-five patients with hemiplegia (right hemiplegia in 21, left hemiplegia in 24) and 20 normal healthy adults were studied. Using three-dimensional motion analysis, an asymmetry index (AI) was calculated from the trajectory of the left-right component at the midpoint between two acromion markers as a function of time. Normal range of the sit-to-stand and stand-to-sit duration was calculated as the mean ± SD obtained from normal subjects. Patients were divided into two groups according to duration: normal duration (within the mean ± 2SD of normal subjects) and abnormal duration (outside the mean ± 2SD of normal subjects). Motor function of the affected lower extremity and other parameters were compared between the normal and abnormal duration groups.
Results: Sit-to-stand and stand-to-sit duration was significantly prolonged in both right hemiplegic and left hemiplegic patients compared with normal subjects. In left hemiplegic patients, AI was significantly higher in those with abnormal duration for both sit-to-stand and stand-to-sit movements. In left hemiplegic patients, the lower extremity motor function was significantly poorer in those with abnormal duration for sit-to-stand movement.
Conclusion: In patients with left hemiplegia, AI deviates toward the unaffected side, and impaired lower extremity motor function is associated with prolonged sit-to-stand duration.
Key words: sit-to-stand and stand-to-sit motion analysis, sit-to-stand and stand-to-sit duration, asymmetry, asymmetry index

Introduction

Standing up from a seated position (sit-to-stand) and sitting down from a standing position (stand-to-sit) are two frequently performed activities in daily living. The sit-to-stand movement involves a postural change from a seated position to a standing position, in which the hip joint acts as the center of rotation to tilt the trunk and the pelvis forward, transferring the center of gravity to the front. Then, the buttocks leave the chair and the center of rotation is transferred to the knee joint to extend the lower extremities and trunk toward a standing position [1]. The stand-to-sit movement generally follows a reverse path of the sit-to-stand movement although there are some differences in afferent and efferent muscle contractions [2].

A multitude of studies have been published on sit-to-stand and stand-to-sit movements [3−9]. Cheng et al. [6] reported that the majority of hemiplegic patients with a history of falls exhibited delayed activation of the tibialis anterior muscle and premature activation of the soleus muscle in the hemiplegic limb. In another study on hemiplegic patients, Duclos et al. [7] reported

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that with both feet positioned spontaneously, asymmetry was observed with the center of pressure greatly deviated toward the unaffected side; whereas with the affected foot placed behind the unaffected foot, near symmetry was obtained. Roy et al. [9] reported that the time for performing the stand-to-sit task was longer than that for the sit-to-stand task in hemiplegic patients. In the clinical setting, when patients with hemiplegia rise from a seated position or sit down from a standing position, asymmetry is often observed; for example, body weight is not loaded on the affected side, and the neck and trunk are tilted toward the affected side. However, to the best of our knowledge, there are no reports that focus on the side-to-side asymmetry and movement execution time in hemiplegic patients.

The objective of the present study was to use three-dimensional motion analysis to elucidate the relationship between asymmetry and execution time for sit-to-stand (sit-to-stand duration) and stand-to-sit movements (stand-to-sit duration) in patients with hemiplegia caused by cerebrovascular disorders.

Subjects and methods

1. Subjects

Twenty normal healthy adults (mean age 24 years, 173.0 ± 4.6 cm in height, 63.2 ± 6.4 kg in weight) and 45 patients with hemiplegia (right hemiplegia in 21, left hemiplegia in 24) were studied. Hemiplegic patients were excluded from this study if their general condition was unstable; if they were not capable of voluntary movements due to impaired consciousness; could not follow instructions from therapists; required the use of a handrail, cane or orthosis for sit-to-stand and stand-to-sit movements; or were judged unsuitable for an evaluation lasting a maximum of approximately 40 min. The clinical profile of the hemiplegic patients is shown in Table 1. Motor function was assessed using the Stroke Impairment Assessment Set (SIAS) [10]. Muscle tone was assessed using the Modified Ashworth Scale (MAS). Activities of daily living were assessed using the Functional Independence Measure (FIM) [11].

This study was reviewed and approved by the Epidemiological and Clinical Research Ethics Committee of our institution (Approval number: 10-118). A detailed explanation of the study was given both orally and in writing to each subject, and informed consent was obtained from all participating subjects.

2. Method of measurement

A subject was seated on the seat of an armless, backless chair, with both arms folded across the chest, and was instructed to perform sit-to-stand followed by stand-to-sit tasks. The height of the seat was adjusted so as to be the height from the floor to the lateral epicondyle of the femur while the subject was seated. The sitting depth was set to be the proximal one-third of the thigh length. None of the subjects used a handrail, cane or orthosis. As the starting position of the lower extremities, the two feet were positioned with 10° ankle dorsiflexion and a distance of 10 cm between the medial malleoli. The speed of movement was not controlled. After practicing repeatedly and confirming safety, measurement was conducted once. Two physical therapists each were positioned on the anterior side and lateral side of the patient as a precaution against falling.

Color markers were placed at 15 sites on the subject's body: top of the head, and bilateral preauricular points, acromia, iliac crests, hip joint

Table 1. Clinical profile of hemiplegic patients.

	Right hemiplegia	Left hemiplegia
Diagnosis	Cerebral infarction 8 patients, cerebral hemorrhage 11, subarachnoid hemorrhage 1, others 1	Cerebral infarction 16 patients, cerebral hemorrhage 5, subarachnoid hemorrhage 2, others 1
Number of cases	21 patients	24 patients
Gender	13 males, 8 females	14 males, 10 females
Age	63±10 (49−84) years	61±16 (24−86) years
Height	160.7±8.8 (146.0−180.0) cm	160.8±9.2 (143.5−177.0) cm
Weight	58.4±10.4 (38.0−77.0) kg	57.4±10.7 (40.0−74.0) kg
Duration after onset	199.6±414.4 (21−1581) days	122.1±216.1 (20−1082) days
SIAS lower extremity total score*	Score 15−13: 7 patients, score 12−10: 5, score 9−7: 4, score 6−4: 5, score 3−0: 0	Score 15−13: 6 patients, score 12−10: 8, score 9−7: 6, score 6−4: 4, score 3−0: 0

*SIAS (Stroke Impairment Assessment Set) scores for three lower extremity function subscales (maximum score: 15) (one-third distance from the great trochanter on a line joining the anterior superior iliac spine and great trochanter), knee joints (midpoint of the anteroposterior diameter of the lateral femoral epicondyle), ankle joints (midpoint of the lateral malleolus), and 5th metatarsal heads.

A three-dimensional motion analysis system, KinemaTracer® (Kissei Comtec Co., Ltd., Matsumoto, Japan) was used. The KinemaTracer® is composed of a computer for recording and analysis, together with four CCD cameras. This system is very convenient for three-dimensional motion analysis (Figure 1) because the CCD cameras and computer are connected with IEEE1394 cables, so there is no need to synchronize the cameras during video recording, a procedure that is required in conventional systems.

A pressure sensor 1.5 cm in diameter was placed on the seat, and pressure change was sampled at a frequency of 100 Hz to detect "seat-off" (when the buttocks lift off the seat) defined as the time of the disappearance of weight on the seat, and "seat-on" (when the buttocks touch the seat) defined as the time when weight starts to load on the seat. The pressure sensor was connected to an AD converter and was synchronized with the KinemaTracer® system. The angle (α) formed by the three markers at the acromion, hip joint and knee joint was defined as the hip joint angle. Motion initiation was indicated by the first change in α of 0.5° or greater in 1/60 s, and motion completion was indicated by the loss of change in α of 0.5° or greater [12]. After completing the sit-to-stand task, an interval of 3 s was applied before starting the stand-to-sit task. After the calculated three-dimensional data was smoothed with a 6-Hz filter [9, 13], the left-right component (x coordinate) and the anterior-posterior component (y coordinate) of each marker were analyzed off-line, using the midpoint of the line joining the left or right ankle and the midpoint of the 5th metatarsal head as 0.

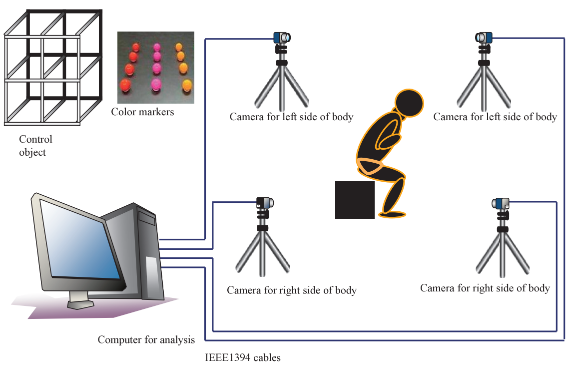

Figure 1. Schematic diagram illustrating the sit-to-stand and stand-to-sit motion analysis.
The KinemaTracer® motion analysis system is composed of a computer for recording and analysis together with four CCD cameras set around the subject. The computer and the CCD cameras are connected by IEEE1394 cables, and synchronization of the cameras during recording is not required.

3. Data analysis

As an indicator of side-to-side asymmetry, an asymmetry index (AI) was determined by calculating the area under the motion trajectory of the left-right component (x coordinate) at the midpoint between the two acromion markers, divided by the time taken (Figure 2). A positive AI value denotes the unaffected side, and a negative value denotes the affected side.

The time taken from initiation to completion of the sit-to-stand and stand-to-sit movements was measured as the sit-to-stand duration and stand-to-sit duration, respectively. The normal range of duration was calculated from the mean ± 2 × standard deviations (SD) of normal healthy adults. The hemiplegic patients were divided into two groups according to movement duration: normal duration (within the mean ± 2SD of normal adults) and abnormal duration (outside the mean ± 2SD of normal adults). The two groups were compared with respect to AI; SIAS scores for affected lower extremity motor function (hip-flexion, knee-extension, foot-pat), quadriceps strength of unaffected side, and lower extremity position sensation and visuospatial perception; MAS; as well as motor and cognitive subscales of FIM.

The difference between sit-to-stand and stand-to-sit duration was compared in normal subjects, right hemiplegic patients, and left hemiplegic patients using

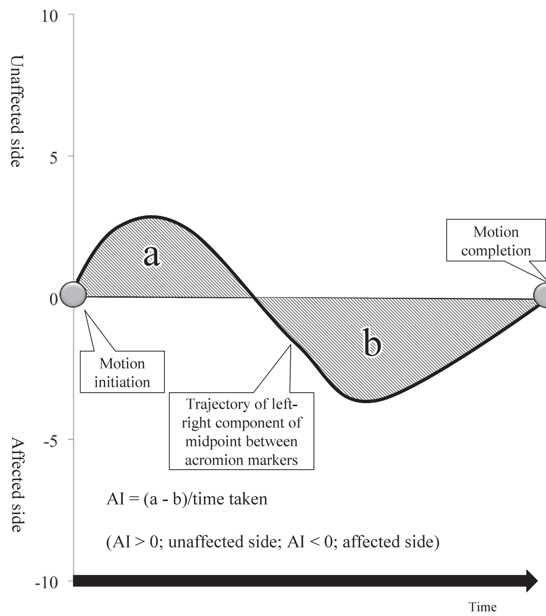

Figure 2. Calculation of the asymmetry index (AI).
AI is calculated from the trajectory of the left-right component (x coordinate) at the midpoint between two acromion markers. AI=(a−b)/time taken. a: area of unaffected side; b: area of affected side. Plus denotes displacement to the unaffected side. Minus denotes displacement to the affected side.

the paired t-test. Other items were compared using the unpaired t-test. A p value less than 0.05 was considered statistically significant. Statistical analyses were conducted using IBM PASW® Statistics 18.

Results

No significant differences in age, height, weight, and duration after onset were observed between right hemiplegic and left hemiplegic patients. The SIAS score for quadriceps strength of the unaffected side was 3 for both right and left hemiplegic patients.

The sit-to-stand duration was 1.83 ± 0.38 s (mean ± SD) in normal subjects, 2.42 ± 0.91 s in right hemiplegic patients, and 2.66 ± 1.31 s in left hemiplegic patients. No significant difference was observed between right hemiplegic and left hemiplegic patients, but the duration in both hemiplegic groups was significantly prolonged compared to normal subjects (p=0.010 for right hemiplegia, p=0.009 for left hemiplegia). The stand-to-sit duration was 1.92 ± 0.36 s in normal subjects, 2.65 ± 0.91 s in right hemiplegic patients, and 3.15 ± 1.29 s in left hemiplegic patients. Likewise, no significant difference was observed between right hemiplegic and left hemiplegic patients, but the duration in both hemiplegic groups was significantly prolonged compared to normal subjects (p=0.002 for right hemiplegia, p=0.001 for left hemiplegia). In left hemiplegic and right hemiplegic patients, the stand-to-sit duration was significantly longer than the sit-to-stand duration (p=0.023 for right hemiplegia, p=0.005 for left hemiplegia).

In 15 right hemiplegic and 15 left hemiplegic patients, the sit-to-stand duration was normal (within the mean ± 2SD of normal subjects), while in 6 right hemiplegic and 9 left hemiplegic patients, the duration was abnormal (outside the mean ± 2SD of normal subjects) (Figure 3). In 11 right hemiplegic and 11 left hemiplegic patients, the stand-to-sit duration was normal (within the mean ± 2SD of normal subjects), while in 10 right hemiplegic and 13 left hemiplegic patients, the duration was abnormal (outside the mean ± 2SD of normal subjects) (Figure 4).

Table 2 shows the comparison of various parameters between normal and abnormal sit-to-stand and stand-to-sit duration in hemiplegic patients. For sit-to-stand movement, a significant increase in AI (p=0.001) and significant decrease in SIAS scores for hip-flexion

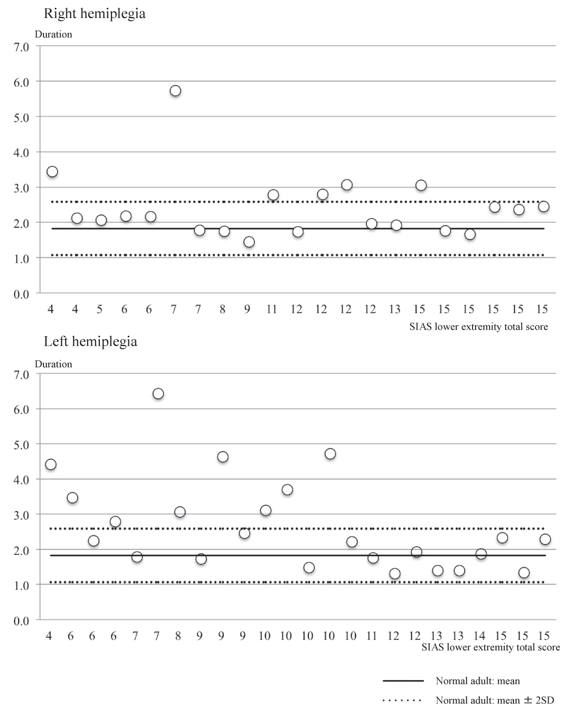

Figure 3. Sit-to-stand duration in right hemiplegic and left hemiplegic patients.
The upper panel shows the sit-to-stand duration in right hemiplegic patients, and the lower panel shows the duration in left hemiplegic patients. The X-axis of the graph shows the SIAS lower extremity total score (maximum score: 15). Dotted lines denote mean ± two standard deviations (2SD) of normal adults. Six right hemiplegic and 9 left hemiplegic patients are outside the mean ± 2SD.

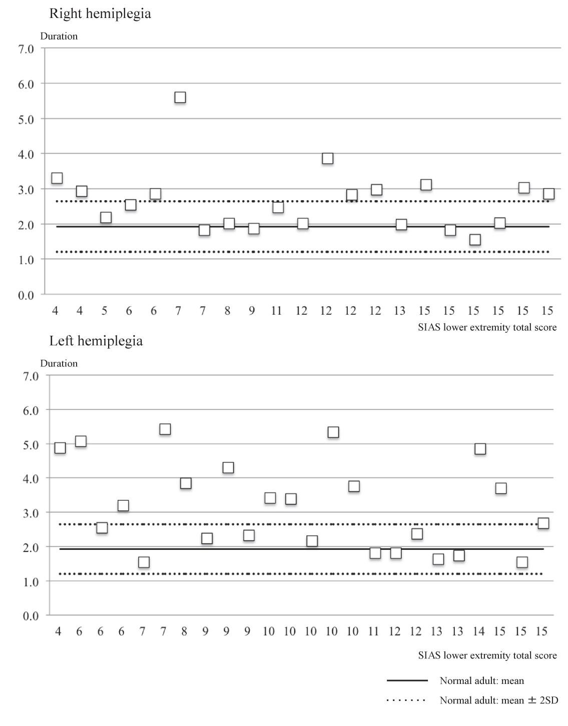

Figure 4. Stand-to-sit duration in right hemiplegic and left hemiplegic patients.
The upper panel shows the stand-to-sit duration in right hemiplegic patients, and the lower panel shows the duration in left hemiplegic patients. The X-axis of the graph shows the SIAS lower extremity total score (maximum score: 15). Dotted lines denote mean ± two standard deviations (2SD) of normal adults. Ten right hemiplegic and 13 left hemiplegic patients are outside the mean ± 2SD.

Table 2. Two-group comparison of normal (within mean ± 2SD of normal subjects) versus abnormal (outside mean ± 2SD of normal subjects) sit-to-stand and stand-to-sit durations in patients with left or right hemiplegia.

			AI	SIAS					MAS	FIM	
				Hip-Flexion	Knee-Extension	Foot-Pat	Position	Visuo-spatial		Motor	Cognitive
Sit to stand	Right hemiplegia	Normal	2.0±2.7	3.6±1.5	3.5±1.3	3.3±1.6	1.9±1.0	2.9±0.3	1.5±1.1	80.0± 8.6	30.6±5.6
		Abnormal	1.9±1.1	3.8±1.0	3.7±1.0	2.7±2.2	2.0±0.9	2.8±0.4	1.2±0.8	78.0± 3.9	34.5±0.5
		P	0.887	0.678	0.809	0.514	0.771	0.505	0.479	0.593	0.112
	Left hemiplegia	Normal	1.0±2.0	4.0±1.0	4.1±0.8	3.3±1.4	2.6±0.7	3.0±0.0	1.6±1.0	76.7± 9.5	32.9±3.0
		Abnormal	4.4±1.4	3.1±1.1	3.0±0.6	2.0±1.1	2.1±0.9	2.8±0.4	1.7±0.7	74.8± 9.7	33.4±3.0
		P	0.001**	0.043*	0.001**	0.010**	0.103	0.060	0.849	0.610	0.692
Stand to sit	Right hemiplegia	Normal	1.7±2.2	3.6±1.4	3.5±1.2	3.4±1.4	1.7±1.0	2.9±0.3	1.6±1.0	82.0± 7.9	30.7±6.4
		Abnormal	0.7±2.4	3.7±1.3	3.6±1.3	2.9±2.1	2.1±0.9	2.9±0.3	1.1±0.9	76.6± 6.1	32.8±2.9
		P	0.334	0.915	0.921	0.556	0.376	0.947	0.212	0.096	0.362
	Left hemiplegia	Normal	1.6±2.5	3.8±1.0	3.8±0.8	3.0±1.5	2.5±0.8	3.0±0.0	1.5±0.9	76.2±10.7	32.5±3.4
		Abnormal	3.9±2.0	3.5±1.3	3.5±1.1	2.6±1.5	2.2±0.8	2.8±0.4	1.8±0.8	75.6± 8.6	33.6±2.6
		P	0.024*	0.446	0.344	0.536	0.363	0.190	0.398	0.889	0.401

Data are expressed as mean ± standard deviation. AI, asymmetry index; SIAS, Stroke Impairment Assessment Set; FIM, Functional Independence Measure.
*p<0.05, **p<0.01, normal duration versus abnormal duration

(p=0.043), knee-extension (p=0.001) and foot-pat (p=0.010) were observed for abnormal duration compared to normal duration in left hemiplegic patients, whereas no significant differences in these parameters were observed between normal and abnormal duration in right hemiplegic patients. For stand-to-sit movement, a significant increase in AI (p=0.024) was observed for abnormal duration compared to normal duration in left hemiplegic patients. For both sit-to-stand and stand-to-sit movements, no differences in SIAS scores for lower extremity position sensation and visuospatial perception, MAS scores, and FIM motor and cognitive scores were found between normal and abnormal duration in both left and right hemiplegic patients.

Discussion

In this study, patients with right hemiplegia showed no significant differences in AI and SIAS scores of lower extremity motor function (affected side) between normal and abnormal duration for both sit-to-stand and stand-to-sit movements. These results suggest that in patients with right hemiplegia, side-to-side asymmetry and motor function of the affected lower extremity are not the cause of the prolonged duration of sit-to-stand and stand-to-sit movements. In patients with left hemiplegia, however, AI was significantly higher in those with abnormal duration compared to normal duration for both sit-to-stand and stand-to-sit movements, while hip-flexion, knee-extension and foot-pat scores were significantly lower only for sit-to-stand movement. Lomaglio et al. [14] reported that since the right hemisphere plays a dominant role in postural control and balance, individuals with left hemiplegia show greater lateral displacement of the foot pressure toward the unaffected side compared to individuals with right hemiplegia, and patients with right hemiplegia may have better postural control than those with left hemiplegia. In a study of the recovery pattern of pushing behavior (PB), which is a characteristic example of impaired postural control, Abe et al. [15] reported that more patients with right cerebral hemisphere damage exhibited PB, and that the duration of recovery from PB was longer with right cerebral hemisphere damage than with left cerebral hemisphere damage. In the present study, patients with left hemiplegia showed displacement of AI to the unaffected side, which prolonged the sit-to-stand and stand-to-sit duration; thus, instruction on rising and sitting, taking into consideration compensation and environment adaptation, would be required to activate the postural control function in these patients. Furthermore, the sit-to-stand duration was prolonged in patients with poorer motor function in the affected lower extremity. One possible explanation is that since the postural control function is worse in left hemiplegia than in right hemiplegia, increased asymmetry is probably not adequately compensated and influences the motor function of the affected lower extremity in patients with left hemiplegia.

Duclos et al. [7] analyzed the sit-to-stand transfer from a horizontal level in hemiplegic patients, and reported a decrease in lateral instability towards the unaffected side when the two feet were placed spontaneously, and towards the affected side when the affected foot was positioned behind the unaffected foot. They concluded that lower extremity motor function and lateral displacement are good clinical indicators as a warning to the risk of falling. Our results also indicate that AI and motor function of the affected lower extremity impact the sit-to-stand and stand-to-sit duration in patients with left hemiplegia, suggesting that these two parameters may also be useful clinical indicators.

Our study demonstrated that the duration of sit-to-stand and stand-to-sit movements was significantly longer in patients with hemiplegia. Roy et al. [9] reported that efferent muscle contraction is necessary during sitting even in hemiplegic patients, and others have reported that during sitting, greater attention is required for seat-on when there is no visual guide, thereby lengthening the movement duration [8, 16] The above factors probably contribute to the prolonged stand-to-sit duration. Moreover, while AI and motor function of the affected lower extremity influenced movement duration in left hemiplegia, these factors had no significant effect in right hemiplegia. Despite this fact, there were no significant differences in the duration of sit-to-stand and stand-to-sit movements between left and right hemiplegia. In the present series, the SIAS score for quadriceps strength of the unaffected side was 3 in both left and right hemiplegia. The same strength level on the unaffected side among left and right hemiplegic patients is probably why there is no difference in movement duration between the two groups.

There are some limitations to this study. First, all the patients studied were able to execute sit-to-stand and stand-to-sit tasks independently or under observation, and did not require the use of a handrail or lower extremity orthosis. The present results thus cannot be extrapolated to suggest whether or not there is a relationship between asymmetry and sit-to-stand and stand-to-sit duration in patients with more serious disabilities, who have to use a handrail or lower extremity orthosis. For such studies, identification of the phases in the sit-to-stand and stand-to-sit movements that show increased asymmetry, and investigation of trial-to-trial variability would be useful. Future studies with a larger number of cases to investigate the effects of using a handrail or lower extremity orthosis on the sit-to-stand and stand-to-sit movements will be useful for the development of effective rising and sitting instruction from an early stage.

References

1. Kanada Y, Tomita M, Sawa S, Okanishi T. Standing up. In: Saitoh E, editor. OSCE for Physical Therapist and Occupational Therapist- A Practical Textbook for Acquiring Clinical Skills. 1st ed. Tokyo: Kanehara Publishers; 2011. p. 142−61. Japanese.
2. Ehara Y, Yamamoto S. Observation of stand to sit. In: Ehara Y, Yamamoto S, editors. Introduction to Body-Dynamics Analysis of Standing up Movement. 1st ed. Tokyo: Ishiyaku Publishers; 2001. p. 65−8. Japanese.
3. Millington PJ, Myklebust BM, Shambes GM. Biomechanical analysis of the sit-to-stand motion in elderly person. Arch Phys Med Rehabil 1992; 73: 609−17.
4. Kelley DL, Dainis A, Wood DK. Mechanics and muscular dynamics of rising from a seated position. In International Series on Biomechanics: Biomechanics V-B. University Park Press; 1976 . p. 127−34.
5. Nuzik S, Lamb R, VanSant A, Hirt S. Sit-to-stand movement pattern: a kinematic study. Phys Ther 1986; 66: 708−13.
6. Cheng PT, Chen CL, Wang CM, Hong WH. Leg muscle activation patterns of sit-to-stand movement in stroke patients. Am J Phys Med Rehabil 2004; 83: 10−6.
7. Duclos C, Nadeau S, Lecours J. Lateral trunk displacement and stability during sit-to-stand transfer in relation to foot placement in patients with hemiparesis. Neurorehabil Neural Repair 2008; 22: 715−22.
8. Mourey F, Pozzo T, Rouhier-Marcer I, Didier JP. A kinematic comparison between elderly and young subjects standing up from and sitting down in a chair. Age Ageing 1998; 27: 137−46.
9. Roy G, Nadeau S, Gravel D, Malouin F, McFadyen BJ, Piotte F. The effect of foot position and chair height on the asymmetry of vertical forces during sit-to-stand and stand-to-sit tasks in individuals with hemiparesis. Clin Biomech 2006; 21: 585−93.
10. Chino N, Sonoda S, Domen K, Saitoh E, Kimura A. Stroke impairment assessment set (SIAS). In: Chino N, Melvin JL, editors. Functional Evaluation of Stroke Patients. Tokyo: Springer-Verlag; 1996. p. 19−31.
11. Fiedler RC, Granger CV. The Functional Independence Measure: A measurement of disability and medical rehabilitation. In: Chino N, Melvin JL, editors. Functional Evaluation of Stroke Patients. Tokyo: Springer-Verlag; 1996. p. 75−92.
12. Kagaya H, Shimada Y, Ebata K, Sato M, Sato K, Yukawa T, Obinata G. Restoration and analysis of standing-up in complete paraplegia utilizing functional electrical stimulation. Arch Phys Med Rehabil 1995; 76: 876−81.
13. Anglin C, Wyss UP. Arm motion and load analysis of sit-to-stand, stand-to-sit, cane walking and lifting. Clin Biomech 2000; 15: 441−8.
14. Lomaglio MJ, Eng JJ. Muscle strength and weight-bearing symmetry relate to sit-to-stand performance in individuals with stroke. Gait Posture 2005; 22: 126−31.
15. Abe H, Kondo T, Oouchida Y, Suzukamo Y, Fujiwara S, Izumi S. Prevalence and length of recovery of pusher syndrome based on cerebral hemispheric lesion side in patients with acute stroke. Stroke 2012; 43: 1654−6.
16. Manckoundia P, Mourey F, Pfitzenmeyer P, Papaxanthis C. Comparison of motor strategies in sit-to-stand and back-to-sit motions between healthy and Alzheimer's disease elderly subjects. Neuroscience 2006; 137: 385−92.