Original Article

Association of performance of standing turns with physical impairments and walking ability in patients with hemiparetic stroke

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Abstract. [Purpose] The effect of turn direction and relation between turn performance and walking ability in patients with hemiparetic stroke is not clear. The purpose of this study was to determine the effect of turn direction on the performance of standing turns and to examine the relations between turn performance and walking ability in patients with hemiparetic stroke. [Subject and Methods] The participants were 38 outpatients with chronic hemiparesis due to stroke. Turn performance was evaluated using the time and number of steps required to complete a 360° standing turn, and was evaluated for turns toward the paretic side and the non-paretic side. Walking ability was assessed using gait speed in the 10-m walk test, the Timed Up and Go test, and the Functional Ambulation Category. [Results] Thirty-six participants were analyzed, and the time needed for turns and number of steps were similar for turns to the paretic and non-paretic sides. The time needed for turns was correlated walking ability. A turn time of 10.0 s distinguished FAC 5 (independent ambulation in the community) from FAC ≤4 with a sensitivity of 0.94 and specificity of 0.85. [Conclusion] The performance of standing turns was not affected by the turning direction and was closely correlated with walking ability.
Key words: Standing turn, Stroke, Walking

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INTRODUCTION

Changes in direction and turning while standing are common daily activities[1)]. Turning while standing is required when performing activities in narrow spaces, such as a kitchen or bathroom. In community-dwelling elderly individuals, hip fractures are eight times more likely to result from falls sustained while turning than from falls sustained while walking[2)]. Walking and turning are the main contributors to recently discharged patients with stroke falling at home and to elderly people residing in long-term care[3, 4)]. Thus, activities that require turning increase the risk of falls[5)], and this is particularly important in patients with stroke.

Patients with hemiparetic stroke exhibit asymmetric postures and movements due to motor impairments on one side of the body, and often have inadequate weight shifting to the limb on the paretic side while walking[6–11)]. Standing turns require horizontal axial rotation on one leg. Thus, motor impairments on one side of the body will affect the ability to execute standing turns. Patients with stroke also have an impaired ability to reorient axial body segments toward a new direction[12, 13)] and require more steps and more time to turn while walking than able-bodied persons[14–16)]. However, the associations of performance of standing turns with motor impairments and walking ability have not been studied. Although the effect of turning direction on the performance of standing turns has been studied, the results are equivocal. Some studies have reported that performance of the Timed Up and Go test (TUG) is not affected by turning direction[17)], whereas others have reported no effect of turning direction[14, 18, 19)]. It is important that patients are instructed on the direction in which to turn when performing standing turns because efficient movement would cause less fatigue. Thus, it is necessary to clarify the direction in which patients find it easiest to turn. The purpose of the present study was to clarify whether turning direction affects the performance of standing turns and to investigate associations of turn performance with physical impairments and walking ability in patients with stroke. We hypothesized that performance of standing turns toward the non-paretic side would be faster because of the stability of the pivot foot. Moreover, the performance of standing turns would be related to walking ability.

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SUBJECTS AND METHODS

Thirty-eight patients with chronic hemiparesis as a result of stroke sustained at least six months previously were recruited from an outpatient center to participate in this study. The inclusion criteria were the ability to walk at least 10 m with or without a walking aid or ankle foot orthosis and the ability to follow commands. Individuals were excluded if they had disturbed consciousness, dementia, or musculoskeletal conditions that affected performance of turns and walking ability. The Institutional Review Board of the Geriatrics Research Institute and Hospital approved this study, and all participants provided written informed consent to participate.

The ability to turn 360° while standing was assessed using the time and number of steps required to complete a 360° turn at a comfortable pace. No participants had performed any training related to turning while standing. Participants were instructed to turn 360° on the spot in the direction they found it easiest to do so and were then instructed to turn 360° on the spot in the other direction. After several practice trials to familiarize the participants with performing standing turns, the time and number of steps required to complete a 360° standing turn at a comfortable pace were measured once in each direction. The participants were allowed to use their usual walking aids and ankle-foot orthoses.

Physical impairments that might affect walking ability[20] were assessed using the Stroke Impairment Assessment Set[21, 22]. Trunk function was evaluated using the Functional Assessment for Control of Trunk[23]. This treatment-oriented measure includes two static sitting balance items and eight dynamic sitting balance items. Static sitting balance items assess the ability to maintain a sitting position with and without upper limb support. Dynamic sitting balance items assess the ability to (1) reach with an upper limb, (2) lift the pelvis from a table, (3) move the buttocks in the frontal plane, (4) move the buttocks in the sagittal plane, (5) flex the hips individually, (6) flex the hips together, (7) rotate the upper trunk, and (8) flex the shoulder of the unaffected upper limb. The maximum score is 20, with higher scores indicating better trunk function.

Walking ability in the home was assessed using the Functional Ambulation Category (FAC), which includes walking on uneven terrain and walking up and down stairs[24]. The level was rated on the following six-point scale: (0) unable to walk or requires the help of two persons to walk; (1) ambulatory with firm continuous contact with one person; (2) ambulatory with intermittent or continuous support of one person; (3) ambulatory on level surfaces with verbal supervision or stand-by help from one person without physical contact; (4) independent ambulation only on level surfaces; and (5) independent ambulation anywhere, including stairs. In addition, we assessed the 10-m walk test and TUG time[25–27]. For the 10-m walk test, participants walked in a straight line at a comfortable speed for 16 m, including 3-m runways at the start and end of a 10-m test walkway. Gait speed was calculated from the time required to walk across the 10-m walkway. The TUG time was the amount of time required to stand from a seated position, walk forwards 3 m, turn around, walk back to the chair, and sit down. The participants completed these tasks at a comfortable speed and used their usual walking aids and ankle-foot orthoses.

Data were statistically analyzed using SPSS version 19.0 J for Windows. The time and number of steps required to turn were compared across the turn directions (toward the paretic side and the non-paretic side) using paired t-tests. Data from the fastest turn direction were used in the subsequent analyses. The relations of the time and number of steps required to turn with physical impairments (Stroke Impairment Assessment Set scores and Functional Assessment for Control of Trunk score) and walking ability (FAC, gait speed in the 10 m walk test and TUG time) were assessed using Pearson correlation or Spearman's rank correlation coefficients. Receiver operating characteristic curves were generated to compare the diagnostic validity of turn time and gait speed to discriminate FAC 5 from FAC ≤4 and to discriminate FAC ≥4 from FAC ≤3. Optimal cutoff points were determined, and the area under the curve, sensitivity, specificity, positive predictive value, and negative predictive value were calculated. The level of significance was set at $p < 0.05$.

RESULTS

Table 1 shows the characteristics of the 38 participants. Thirty-six participants could perform a 360° standing turn in both directions. One could not turn in both directions, and another could turn only in the direction of the paretic side. The time and number of steps required to turn were similar for turns toward the paretic and turns toward the non-paretic side (n = 36; Table 2). In the faster turning direction, the mean (standard deviation) turn time across 36 participants was 12.5 (9.1) s, and the mean (standard deviation) number of steps was 15.3 (6.5). These values were used in subsequent analyses. Turn time was significantly correlated with the number of steps ($r = 0.739$, $p < 0.01$). Turn time and the number of steps were significantly correlated with paretic motor function and trunk function (hip flexion, knee extension, and foot-pat scores in the Stroke Impairment Assessment Set and Functional Assessment for Control of Trunk score), FAC, gait speed in the 10-m walk test, and TUG time (Table 3).

Table 4 shows the cutoff scores for turn time and gait speed by FAC. The cutoff scores for turn time and gait speed to distinguish FAC 5 from FAC ≤4 were 10.0 s and 0.4 m/s, respectively, and the cutoff score for turn time to distinguish FAC ≥4 from FAC ≤3 was 12.0 s.

DISCUSSION

Healthy elderly individuals require an average of 4.8 s and 7.2 steps to complete a 360° standing turn[28]. In the present study, patients with hemiparetic stroke required an average of 12.5 s and 15.3 steps. These results indicate that the patients with stroke had an impaired ability to turn while standing. These results support reports that patients with stroke have an impaired ability to turn while walking[14, 16, 18], an impaired ability to reorient axial body segments towards a new direction[12, 29], and a decreased step length and stance time of the paretic lower extremity during walking[6–11]. These characteristics would all be expected to impact the performance of turns while standing. However, standing turns are not frequently practiced in a clinical setting. It is possible that practice of standing turns improves performance because task-oriented training improves a specific task. Turning is a main contributor to falling in patients with stroke; therefore, practice may be important for patients with stroke to improve stability or performance in turning.

Our hypothesis that the performance of standing turns would differ between turns towards the paretic and non-paretic sides was not supported by our results. This may be because participants used compensatory strategies to adjust for impairments on the paretic side of the body. Our results support those of Faria et al.[18], who reported that the direction of turning did not affect performance of the TUG test in patients with stroke. The amount of time required to complete a 360° standing turn correlated moderately with motor function in the paretic lower extremity, and correlated well with walking ability. These results agree with those of a previous study[16] and suggest that turning ability is more closely associated with walking ability than with motor function of the paretic lower extremity. In addition,

Table 1. Characteristics of all participants (N = 38)

Variable	Value
Age (years)	69.6±9.8
Gender	
Men	23
Women	15
Diagnosis	
Infarction	18
Hemorrhage	17
Subarachnoid hemorrhage	3
Paretic side	
Left	13
Right	25
Time since stroke onset (days)	1,563.4±1,197.8
Ankle foot orthosis	
Yes	16
No	22
Walking aid	
None	10
T-cane	13
Q-cane	13
Lofstrand crutch	1
Walking frame	1
Stroke Impairment Assessment Set score	
Hip flexion	4 (1–5)
Knee extension	3 (1–5)
Foot-pat	3 (0–5)
Touch	2 (0–3)
Perception of foot position	2 (0–3)
Visual spatial	3 (0–3)
FACT score	10.5 (4–20)
FAC	4 (2–5)
10-m walk test gait speed (m/s)	0.48±0.30
TUG time (s)	35.5±3.2

Data are numbers, mean ± SD, or medians (min–max). FAC, Functional Ambulation Category; FACT, Functional Assessment for Control of Trunk; TUG, Timed Up and Go test

Table 2. Standing turn performance in the paretic and non-paretic direction (n=36)

	Paretic direction	Non-paretic direction
Turn time (s)	13.9±9.1	13.5±8.5
Turn of steps	16.3±8.5	16.1±6.5

Data are means ± SD

Table 3. Correlation of standing turn performance with physical impairments and walking ability

	Turn time	Number of steps
Stroke Impairment Assessment Set score		
Hip flexion	−0.413*	−0.134
Knee extension	−0.501**	−0.361*
Foot-pat	−0.507**	−0.244
Touch	−0.430**	−0.114
Perception of foot position	−0.315	0.028
Visual spatial	0.03	0.006
FACT score	−0.748**	−0.530**
FAC	−0.748**	−0.543**
10-m walk test gait speed	−0.761††	−0.589††
TUG time	0.775††	0.499††

FAC, Functional Ambulation Category; FACT, Functional Assessment for Control of Trunk; TUG, Timed Up and Go test
Data are Spearman's rank correlation coefficients or Pearson correlation coefficients.
* Spearman's rank correlation coefficient $p < 0.05$
** Spearman's rank correlation coefficient $p < 0.01$
†† Pearson correlation coefficient $p < 0.01$

Table 4. Discriminative properties of the amount of time required to execute a 360° standing turn and gait speed (n=36)

Distinguish	Measurement	Cut off score	AUC	Sensitivity	Specificity	PPV	NPV
FAC 5 from FAC ≤4	Standing turn time	10.0 s	0.92	0.94	0.85	0.83	0.94
	10MWT gait speed	0.4 m/s	0.96	0.84	1.00	1.00	0.85
FAC ≥4 from FAC ≤3	Standing turn time	12.0 s	0.87	1.00	0.63	1.00	0.63

AUC, area under the curve; PPV, positive predictive value; NPV, negative predictive value; 10MWT, 10-m walk test turn time and number of steps were both closely correlated with trunk function. This indicates that standing turns require trunk stability with lower limb movements and agrees with the finding that trunk function is closely associated with standing balance[30].

The cutoff value for distinguishing FAC 5 from FAC ≤4 was 10 s for standing turn time and 0.4 m/s for gait speed. FAC 5 indicates the ability to ambulate in the community, suggesting that these cutoffs could be used to identify patients capable of community ambulation. These results support a previous study that reported a cutoff gait speed of 0.4 m/s for household and community walkers, including those with and without functional walking limitations[22]. Standing turn time distinguished FAC 5 from FAC ≤4 with high sensitivity and specificity and with similar discriminative power as gait speed. Standing turn time also had good sensitivity and specificity to distinguish FAC ≥4 from FAC ≤3. FAC 4 indicates the ability to ambulate without the help of others. Standing turn time can be easily and rapidly measured in a small space, in contrast to gait speed in the 10-m walk test, which requires a long walk-way. Thus, measurement of standing turns in useful for distinguishing community ambulators and ambulators without the help of others. One of the limitations of this study is that we only studied patients with chronic stroke, and our results may not be generalizable to patients with acute stroke. Moreover, turn speed, walking aids, and turning strategies, including the turning diameter and the use of a pivot, were not controlled but might affect the outcome measures.

In conclusion, we investigated the performance of standing turns towards the paretic and non-paretic sides and the relations of standing turn performance with functional impairments and walking ability in patients with chronic stroke. Standing turn performance did not differ for turns to the paretic and non-paretic sides. Standing turn time was a useful indicator of community ambulators.

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