



Characteristics of Sit-to-Stand from a Western-Style Toilet When Putting on Pants in Patients with Hemiplegia Who are Toilet Independent: A Preliminary Study

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Abstract

Introduction: Studies of independent toileting in hemiplegic stroke patients have examined patients' ability to perform sit-to-stand (STS) motion from a Western-style toilet; however, the characteristics of the STS motion performed in conjunction with pulling up of pants (toileting) remain unclear. This study elucidated the characteristics of toileting based on the differences in the center of pressure (COP), force on the foot sole (foot force), and trunk acceleration during toileting in hemiplegic patients under conditions similar to those of daily life.

Methods: Ten male hemiplegic patients participated in this study. Measurements were taken using a foot pressure distribution analysis tool and portable three-dimensional motion analysis tool. Based on video recordings, STS and toileting tasks were divided into four phases (P1–P4), and each phase was analyzed. STS and toileting tasks were evaluated and compared.

Results: Eight participants exhibited "Pattern A," which involved increased displacement of the COP toward the paretic side during toileting compared to that during STS. Two participants exhibited "Pattern B," which involved decreased displacement of the COP toward the paretic side during toileting compared to that during STS. Comparisons between STS and toileting showed that the phase from maximum dorsiflexion to full hip extension (P3) was significantly different for maximum displacement of the COP in the paretic side direction (STS, -4.7 ± 9.17 ; toileting, 8.6 ± 14.12 ; $p < .05$) and the maximum foot force on the paretic side direction (STS, 42.6 ± 6.03 ; toileting, 53.4 ± 11.25 ; $p < .05$). Furthermore, the maximum trunk acceleration, which reflects the magnitude of the force applied to the body, was significantly different in the paretic side direction (STS, 0.04 ± 0.01 ; toileting, 0.09 ± 0.03 ; $p < .01$) and non-paretic side direction (STS, 0.04 ± 0.01 ; toileting, 0.09 ± 0.03 ; $p < .01$).

Conclusion: Our findings suggest that the characteristics of toileting and STS differ in hemiplegic stroke patients. Occupational therapists and physiotherapists need to provide independent toileting. Activity instructions to hemiplegic stroke patients that cover the actual toileting motion in addition to the STS motion.

Keywords: Activity Of Daily Living; Occupational Therapy; Center Of Pressure; Motion Analysis; Rehabilitation; Stroke; Toileting

Introduction

Hemiplegic stroke patients highly require toileting independence. Families often describe it as a condition for patients to return home. The series of toilet activities related to excretion require a composite of tasks such as moving, changing clothes, transferring, and hygiene. Reports suggest that toilet activity tasks are ranked from most difficult to least difficult in the following order: putting on pants, opening and closing the door, taking off pants, and changing direction [1]. Moreover, early reports have suggested that toilet activity independence in hemiplegic stroke patients is affected by the following functions in this order: lower limb function, cognitive function, and trunk function [2]. As an index for evaluating activities of daily living (ADL), the Functional Independence Measure (FIM) is often used. The scored items for toilet activity in the FIM include putting on and taking off pants and cleaning the pubic area. They do not include opening and closing doors or transferring to the toilet seat [3]. However, research into toilet motion has emphasized the sit-to-stand (STS) motion from a Western-style toilet. Studies have examined topics such as differences in toilet seat height [4] and standing up from a Western-style toilet using a single cane [5]. Recently, studies have assessed the putting on of pants in a standing posture [6-8]. Nevertheless, these studies evaluate only a part of the overall composite of toilet activities, with results expected to differ from those of an examination of a series of toilet motions including standing up.

In studies conducted to date, force plates have been widely used to evaluate standing motion. In addition, a systematic review of the standing motion of hemiplegic stroke patients revealed characteristics such as a shift of the trunk toward the non-paretic side, asymmetric weight bearing and knee joint moment, and center of pressure

(COP) displacement to the non-paretic side [9]. Recently, some reports have described the use of an accelerometer as an evaluation index for balance and trunk sway during standing motion [10], quiet standing [11], and walking [12].

It is often difficult for a hemiplegic patient to put on and remove pants during toilet motion, even if they can execute a standing motion from the toilet seat. STS with the putting on of pants (toileting) is a dual task. It may increase asymmetry in hemiplegic stroke patients more than STS. This study was designed to compare STS and toileting and elucidate the characteristics of toilet motion based on differences in the COP and force on the sole of the foot (foot force) and trunk acceleration during motion.

Materials and Methods

Participant Information

The participants were 10 male hemiplegic stroke patients recruited at a local hospital. The inclusion criteria were as follows: 1) hemiplegia related to stroke, 2) ability to stand from a Western style toilet, and 3) ability to pull up and pull down pants independently (6 or 7 FIM toileting items). The exclusion criteria were as follows: 1) cognitive dysfunction affecting comprehension of the task, 2) musculoskeletal disorders affecting standing motion, 3) Parkinson's disease, and 4) higher brain dysfunction that may affect task performance, such as unilateral spatial neglect or attention deficit. The participant characteristics are shown in Table 1. This study was approved by the Ethics Committee of Yamagata Prefectural University of Health Sciences (No. 1809-15) and the Ethics Committee of Yamagata Saisei Hospital (No. 383). Consent was received from participants after written and oral explanations.

ID	Affected side (Rt/Lt)	Diagnosis	Age (y)	Sex	Height (cm)	Weight (kg)	Time since onset (months)	Br. stage U/E-Finger-L/E	FMA		BBS	MMSE	Hands used to put on pants	Gait aid
									U/E	L/E				
1	Rt	Pontine infarction	83	M	153	58.1	3	V-V-V	54	30	50	28	Both hands	No
2	Lt	Putaminal hemorrhage	54	M	171	66.3	5	IV-V-IV	48	29	52	30	Non Paretic hand	Yes
3	Rt	Putaminal hemorrhage	69	M	175	68.7	1	V-V-V	54	34	43	20	Both nonos	No
4	Rt	Corona radiata and putamen infarcts	56	M	167	70.9	30	IV-V-V	62	20	45	30	Non Paretic hand	No

5	Lt	Thalamic hemorrhage	45	M	163	57.5	2	V-V-V	65	34	50	30	Both hands	No
6	Rt	Putaminal hemorrhage	61	M	170	82	3	IV-V-V	52	27	50	30	Non Paretic hand	Yes
7	Lt	Thalamic hemorrhage	58	M	169	63.1	3	V-V-V	44	31	54	30	Both hands	Yes
8	Rt	Putaminal hemorrhage	60	M	162	65.0	20	V-V-V	57	32	55	30	Non Paretic hand	No
9	Lt	Corona radiata and putamen infarcts	48	M	170	87.2	4	V-V-IV	50	48	54	30	Both hands	No
10	Rt	Basal ganglia and frontal temporal infarcts	68	M	180	74.7	23	IV-V-V	49	27	53	30	Non Paretic hand	Yes
Mean	Rt: 6	Infarction: 4	60.2		168.1	69.4	9.4		54	29	51	29	Both hands: 5	Y: 4
SD	Lt: 4	Hemorrhage: 6	11.1		7.4	9.7	10.6		6	4	4	3	Non Paretic hand: 5	N: 6
Range			48-83		153-180	7.5-82	1-30		44-62	20-34	43-55	20-30		

Table 1: Characteristics of participants.

Brunnstrom recovery stage (Br:stage), Fugl-Meyer Assessment (FMA), Berg Balance Scale (BBS), Mini-mental State, Examination (MMSE)

Experimental Equipment

Participants wore trousers (pants, TR-9A1238JP; Alpine, Inc., Nagoya, Japan) over their underwear (TR-3R1084UP; Alpine, Inc., Nagoya, Japan). The actual clothes used differed according to waist sizes (S, M, L, 2L, and 3L). The height of the Western-style toilet (TS-FX805P-B; Takara Standard Co., Ltd., Osaka, Japan) (SCS-TS200D-1; Toshiba Corp., Tokyo, Japan) was 42 cm above the floor. Measurements were performed using a foot pressure distribution analysis tool (EM-MP2703; Sakai Medical Co. Ltd., Tokyo, Japan), a portable three-dimensional motion analysis tool (EM-M07; Sakai Medical Co. Ltd., Tokyo, Japan), and two video cameras (C920; Logitech Corp., New York, USA). The motion sensor of the portable three-dimensional motion analysis tool was fixed with a belt at the level of the spinous process of the fourth lumbar vertebra. The video camera was positioned so that the whole body could be photographed in the frontal and sagittal planes. The time resolutions of the foot pressure distribution analysis tool and the portable three-dimensional motion analysis tool were both 100 Hz. The spatial resolution was 16 bits for both. The time resolution of the video camera was 30 Hz. The spatial resolution was 998,400 pixels (1,280 × 780). All

devices were synchronized and measured using software (MR3 ver. 3.12; Sakai Medical Co. Ltd., Tokyo, Japan).

Experimental Task

This experiment assessed two types of tasks: Task 1 was STS and Task 2 was toileting.

Task 1 involved standing up without using the upper limbs from a seated position on a Western-style toilet. The examiner instructed the participant to stand up from the sitting position in response to a signal and place his hands next to his body after completing the motion. The following instructions were given regarding the position of the feet: "Please keep your feet in a position that allows you to stand up safely without moving them" and "Do not shift the position of your left and right feet back and forth."

Task 2 involved standing up and pulling up pants from a seated position on a Western-style toilet. The examiner instructed the participant to stand up while pulling up his pants in response to a signal and place his hands next to his body after the motion was completed. The time taken to pull up the pants was defined as the time from when the waist

part of pants was positioned on the knee joint to the time when it was positioned beyond the superior anterior iliac spine. The timing of pulling up the pants, motion procedure, and limbs to be used were determined arbitrarily by the participant. The participants were instructed to perform the task as they usually would. The following instructions were given regarding the position of the feet: "Please keep your feet in a position that allows you to stand up safely without moving them" and "Do not shift the position of your left and right feet back and forth."

Procedure

The participants were allowed to stand on the plate with their feet in the same position they used for normal toilet activity. The examiner calibrated the foot pressure distribution analysis tool and the portable three-dimensional motion analysis tool. Task 1 was performed before Task 2. Each task was measured five times after several practice attempts. The participants rested for 2 min between Task 1

and Task 2.

Data Analysis

Data obtained from each sensor were processed using software (MATLAB 2019a; MathWorks Inc., Natick, Massachusetts, USA). The raw data included noise; hence, a low-pass filter was used. The cutoff frequency was 10 Hz [13].

Separation of STS and Toileting Tasks

Based on the video, both the STS and toileting tasks were classified into four phases (Figure 1). Phase 1 (P1) was the duration from the beginning of any movement of the body to liftoff. Phase 2 (P2) was the duration from liftoff to maximum ankle dorsiflexion. Phase 3 (P3) was the duration from maximum dorsiflexion of the ankle to the full extension of the hip. Phase 4 (P4) was the duration from hip extension to the end of movement [14].

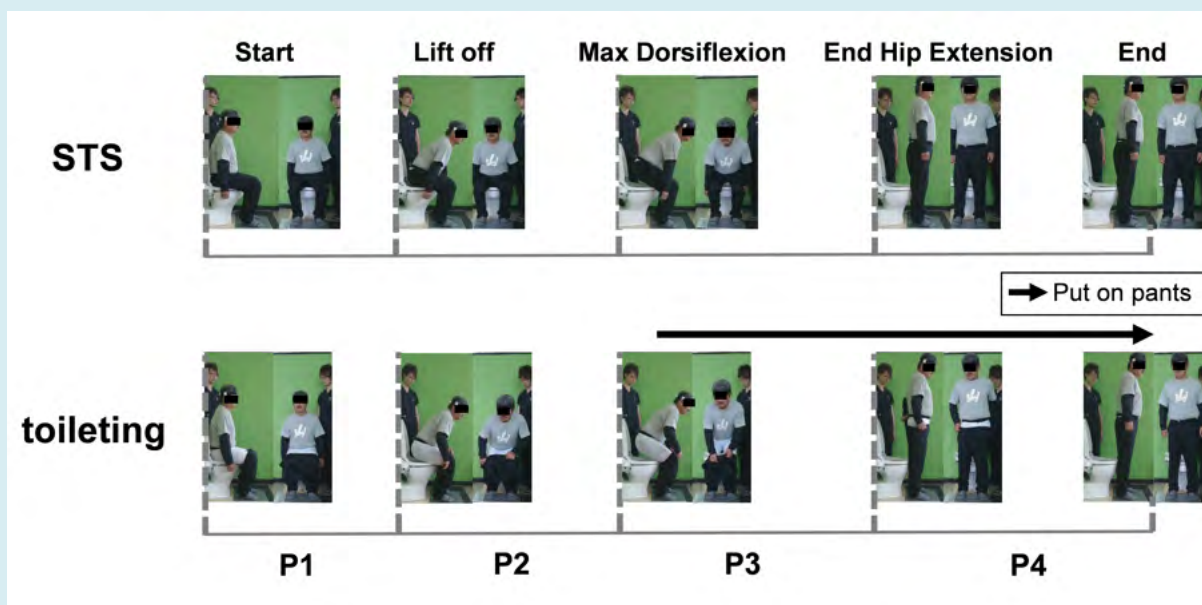


Figure 1: Sit-to-stand from a Western style toilet (STS) and STS during putting on of the pants (toileting) start to end are classified into four phases (P).

The figure shows still images from the sagittal plane and the frontal plane at the start and end of P1–P4 each of STS and toileting: P1, from the beginning of any movement of the body to the annulment; P2, from the annulus to the maximum dorsiflexion of the ankle; P3, from the maximum dorsiflexion of the ankle to full extension of the hip; and P4, from the full extension of the hip to the end of the motion. The black arrow in the figure indicates the period from the start to the end of putting on the pants.

Data Calculation and Normalization Processing

The time taken for the entire motion was represented as 100%, with each phase attributed a certain "percent of motion" [15]. The distance from the toe to the heel was defined as the foot length (FL). The distance between the

outer edges of both feet was defined as the foot distance (FD) and was calculated using image software (Image J; <http://rsbweb.nih.gov/ij>) [16]. From the foot pressure distribution analysis tool, we calculated the anterior–posterior (AP) and medial–lateral (ML) COP displacement and force on the sole of the foot (foot force) applied to the paretic and non-

paretic sides. The COP displacement was normalized by dividing the AP direction COP displacement by the FL and the ML direction COP displacement by the FD to remove the influence of individual foot position and foot size [17]. Force on the foot sole was normalized by dividing by the weight of the individual participant to remove the effect of weight on the results [18]. P1 before liftoff was excluded from the measurement restrictions of the foot pressure distribution analysis tool. Data from P2, P3, and P4 were used for analyses. From the portable three-dimensional motion analysis tool, the authors obtained data on trunk acceleration in each of the AP, ML, and vertical directions to determine the magnitude of the force applied to the body.

Statistical Analyses

Measured data from P2 to P4 were analyzed. The maximum values of COP displacement in each direction, foot force on the paretic side and non-paretic side, and trunk acceleration in each direction were processed using statistical analysis software (SPSS ver. 22; SPSS Inc., Chicago, IL, USA). The Shapiro–Wilk test was applied to confirm the presence or absence of normality. The paired Student's *t* test was used if the distribution was normal. The Wilcoxon test was used if the distribution was not normal. The significance level of each test was 5%. The effect size was calculated using Cohen's [19].

Results

Comparison of the Total COP Trajectory

The total COP trajectories projected on the bilateral plantar images of STS and toileting are shown in Figure 2. The difference in the transition of the COP between STS and toileting was distinguishable by two patterns. Those who showed Pattern A had increased displacement of the COP toward the paretic side during toileting compared to STS. In one example (# 1) shown in the upper panel of Figure 2, during STS, the COP trajectory changed on the non-paretic side from start to end. During toileting, however, the COP started almost at the center of the posterior direction, moved forward, backward, left, and right and moved forward from the center at the end. Eight of the 10 participants showed a pattern similar to Pattern A (# 1–8). In eight participants, the COP moved on the non-paretic side during toileting, as in STS; however, in some participants, the COP was temporarily displaced to the paretic side during motion. Participants who showed Pattern B had a greater decrease in the displacement of the COP toward the paretic side during toileting than during STS. In one example (# 9) shown in the lower panel of Figure 2, during STS, the COP trajectory was always on the non-paretic side from start to end. During toileting, the COP always remained on the non-paretic side. The displacement decreased more toward the paretic side during toileting than during STS, increasing the asymmetry. Two out of 10 participants showed a pattern similar to Pattern B (# 9–10).

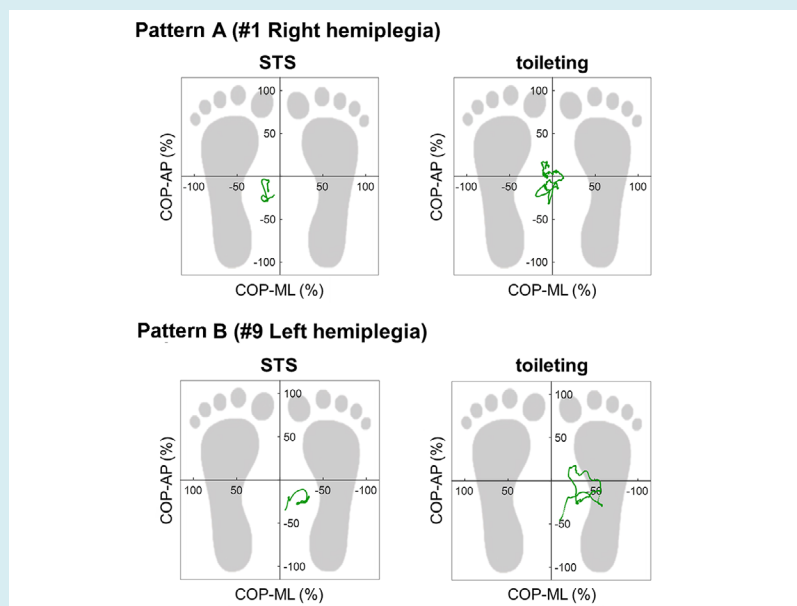


Figure 2: Example showing comparison of the total trajectory of center of pressure (COP). Left and right present STS and toileting, respectively. The horizontal axis represents the normalized COP medial–lateral (ML) transition, with plus denoting the paretic side and minus denoting the non-paretic side. The normalized COP anterior–posterior (AP) transition is shown, with plus denoting anterior and minus denoting posterior.

Transition in the COP, Foot Force, and Trunk Acceleration in Pattern A

The transitions of COP-AP, COP-ML, foot force on the paretic side and non-paretic side, and trunk acceleration (AP, ML, and vertical) in Pattern A are shown in Figure 3. The STS COP-ML remained on the non-paretic side from the start to the end of the motion. However, the COP-ML changed near the center during toileting while the participant pulled up their pants in P3 and P4. At that time, repeated displacement to the paretic side occurred.

Regarding foot force, during STS, values on the non-paretic side were high during all phases, whereas during toileting, foot force values on the non-paretic side were three times the value in P3 and P4. The paretic side showed high values. Trunk acceleration increased and decreased repeatedly while the participant pulled up their pants in P3 and P4 during toileting but not during STS. The amplitude increased in all directions (AP, ML, and vertical); however, the change in the ML direction was the largest.

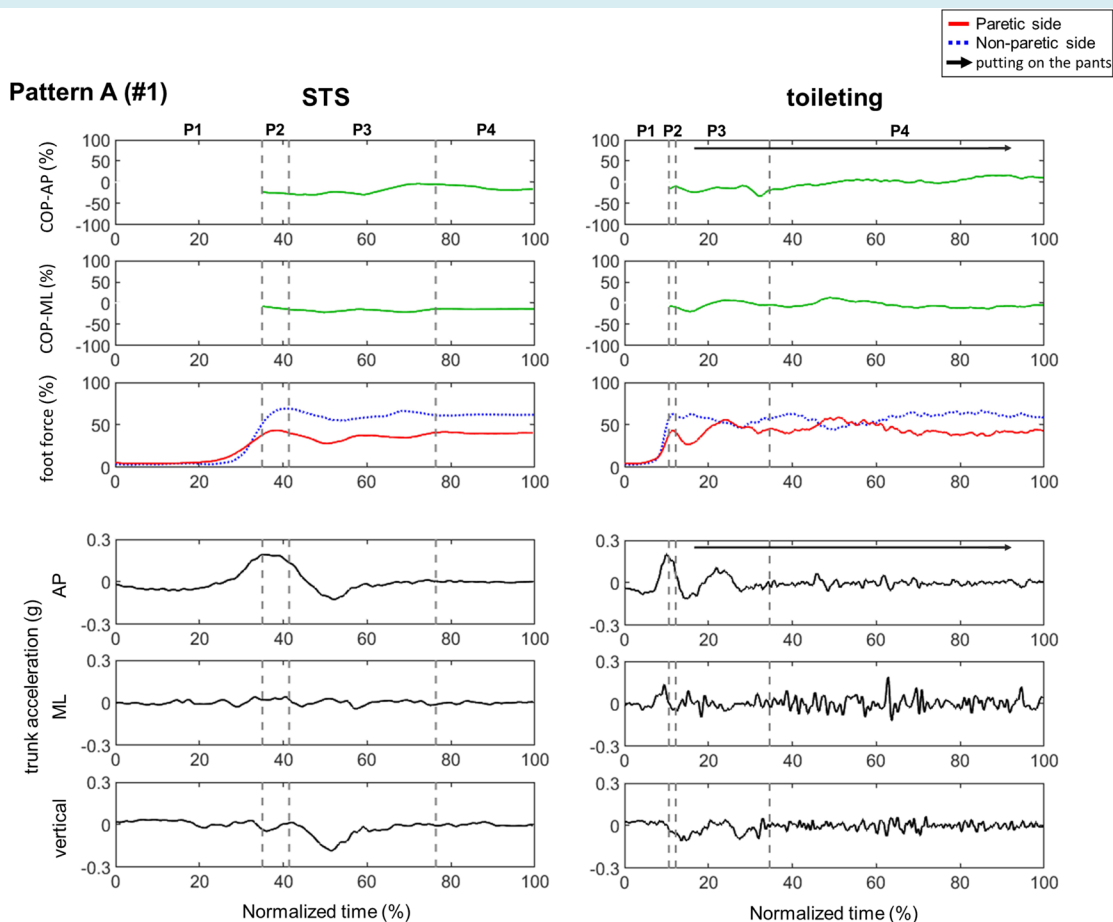


Figure 3: Changes in COP, force on the sole of the foot (foot force), and trunk acceleration in the example showing Pattern A. Left and right show the STS and toileting, respectively. The horizontal axis shows the time required for normalized operation. The vertical axes, respectively, show the changes in COP in the AP directions and ML directions; the changes in foot force on the paretic side and non-paretic side; and the changes in trunk acceleration in the AP, ML, and up-down (vertical) directions. Abbreviations here are used in figure 4.

Transition in the COP, Foot Force, and Trunk Acceleration in Pattern B

The transitions of COP-AP, COP-ML, foot force on the paretic side and non-paretic side, and trunk acceleration (AP, ML, and vertical) in Pattern B are shown in Figure 4. The

results showed that the STS COP-ML always remained on the non-paretic side from the start to the end of the motion.

The toileting COP-ML started from the non-paretic side and then moved further toward the non-paretic side while the participant pulled up their pants in P3 and P4. The foot force

on the non-paretic side increased and the foot force on the paretic side decreased during toileting while the participants pulled up their pants in P3 and P4, and increasing asymmetry was noted on the paretic side and non-paretic side during STS. Trunk acceleration increased and decreased repeatedly

during the pulling up of pants in P3 and P4 during toileting but not during STS. The amplitude increased in all directions (AP, ML, and vertical), with the amplitude in the ML direction showing the highest value.

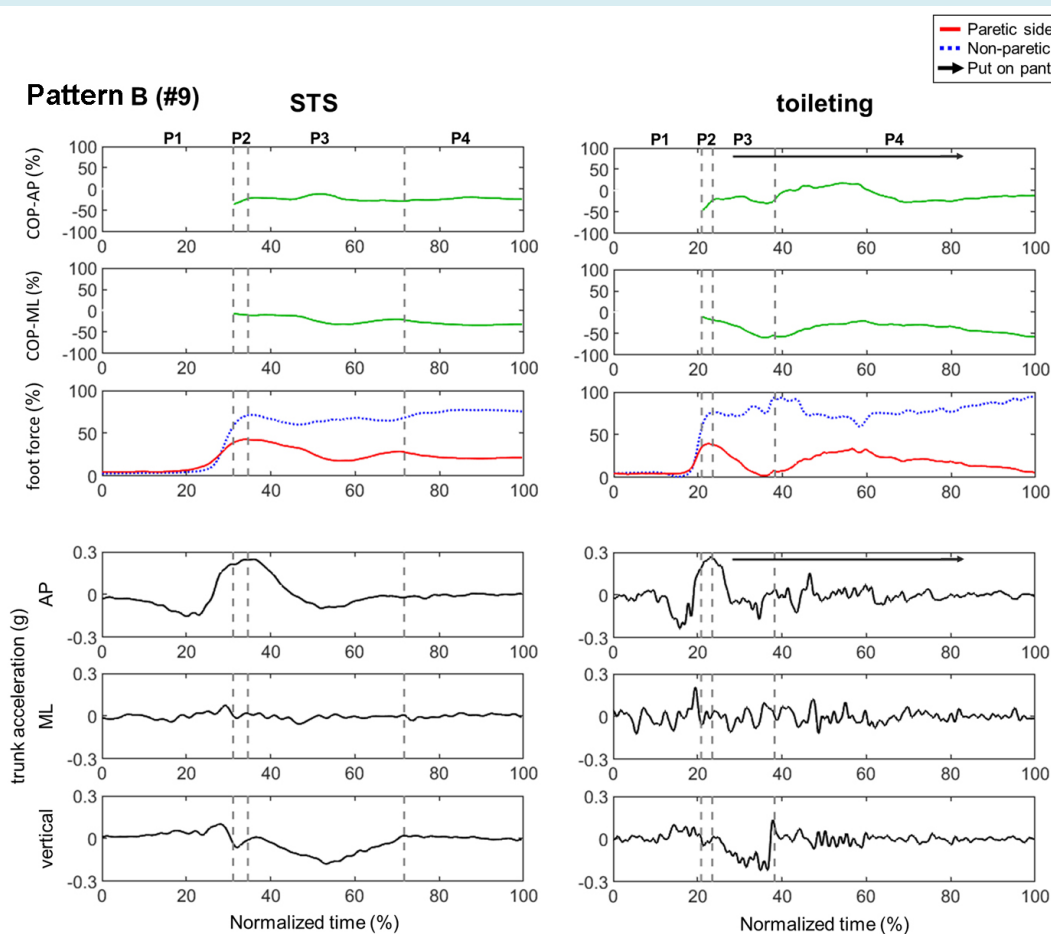


Figure 4: Changes in COP, foot force, and trunk acceleration in the example showing Pattern B.

Comparison of STS and Toileting for all Participants

The results obtained from the comparison of the STS and toileting tasks are shown in Table 2. The maximum displacement of the COP was significantly different in the non-paretic side direction in P2 ($p < .05$, $d = 0.64$). At P3, a significant difference was found in the paretic side direction ($p < .05$, $d = 1.12$). At P4, a significant difference was found in the posterior direction ($p < .05$, $d = 1.08$) and non-paretic side direction ($p < .05$, $d = 1.04$). The maximum foot force was significantly different on the paretic side in P3 ($p < .05$,

$d = 1.20$). In P4, a significant difference was found on the non-paretic side ($p < .01$, $d = 1.10$). The maximum trunk acceleration was significantly different in the posterior direction ($p < .05$, $d = 0.73$) in P2. At P3, a significant difference was found in the posterior direction ($p < .05$, $d = 0.49$) and paretic side direction ($p < .01$, $d = 2.59$), non-paretic side direction ($p < .01$, $d = 2.25$), and up direction ($p < .05$, $d = 0.95$). At P4, significant differences were found in all directions: anterior direction ($p < .01$, $d = 1.59$), posterior direction ($p < .01$, $d = 2.26$), paretic side direction ($p < .01$, $d = 2.59$), non-paretic side direction ($p < .01$, $d = 2.25$), up direction ($p < .01$, $d = 2.76$), and down direction ($p < .01$, $d = 4.22$).

	STS	(SD)	Toileting	(SD)	p-value	(Cohen's d)
Maximum COP-anterior (%)						
P2a	-26.4	(13.72)	-22.1	(16.70)	.103	(0.28)
P3a	1.6	(13.39)	-1.3	(9.28)	.557	(0.25)
P4b	0.5	(11.40)	2.9	(9.83)	.799	(0.23)
Maximum COP-posterior (%)						
P2a	36.3	(17.07)	38.6	(20.34)	.538	(0.12)
P3a	35.4	(12.27)	32.8	(15.50)	.450	(0.19)
P4a	14.6	(8.20)	24.8	(10.48)	.019*	(1.08)
Maximum COP-Paretic side (%)						
P2b	-6.1	(8.14)	-8.8	(7.12)	.093	(0.35)
P3a	-4.7	(9.17)	8.6	(14.12)	.040*	(1.12)
P4a	-6.0	(10.82)	-2.0	(10.37)	.333	(0.38)
Maximum COP-Non-paretic side (%)						
P2b	9.4	(8.28)	14.8	(8.69)	.039*	(0.64)
P3b	21.6	(13.66)	25.2	(14.10)	.285	(0.26)
P4a	14.2	(11.08)	27.0	(13.47)	.005**	(1.04)
Maximum Paretic side foot force (%)						
P2a	42.0	(6.57)	40.1	(7.04)	.098	(0.28)
P3b	42.6	(6.03)	53.4	(11.25)	.028*	(1.20)
P4a	41.2	(8.22)	46.3	(9.61)	.120	(0.57)
Maximum Non-paretic side foot force (%)						
P2a	62.5	(6.21)	63.9	(7.86)	.264	(0.20)
P3b	64.4	(6.21)	67.8	(10.35)	.508	(0.40)
P4a	61.1	(8.06)	71.3	(10.35)	.003**	(1.10)
Maximum Trunk Acceleration-anterior (g)						
P2a	0.17	(0.06)	0.16	(0.06)	.356	(0.17)
P3b	0.11	(0.07)	0.11	(0.06)	.508	(0.00)
P4b	0.02	(0.01)	0.06	(0.04)	.005**	(1.59)
Maximum Trunk Acceleration-posterior (g)						
P2a	-0.10	(0.06)	-0.05	(0.08)	.029*	(0.73)
P3a	0.08	(0.03)	0.10	(0.05)	.044*	(0.49)
P4b	0.02	(0.01)	0.06	(0.02)	.005**	(2.26)
Maximum Trunk Acceleration-Paretic side (g)						
P2a	0.03	(0.03)	0.04	(0.02)	.312	(0.49)
P3a	0.04	(0.01)	0.09	(0.03)	.000**	(2.59)
P4a	0.02	(0.01)	0.11	(0.04)	.000**	(3.13)
Maximum Trunk Acceleration-Non-paretic side (g)						
P2a	0.01	(0.02)	0.03	(0.03)	.321	(0.79)
P3a	0.04	(0.01)	0.09	(0.03)	.000**	(2.25)
P4a	0.02	(0.01)	0.12	(0.03)	.000**	(4.76)
Maximum Trunk Acceleration-up (g)						
P2a	0.00	(0.04)	0.00	(0.04)	.849	(0.05)

P3b	0.03	(0.02)	0.06	(0.04)	.047*	(0.95)
P4a	0.02	(0.01)	0.07	(0.02)	.001**	(2.76)
Maximum Trunk Acceleration-down (g)						
P2b	0.07	(0.05)	0.07	(0.03)	.878	(0.00)
P3b	0.12	(0.04)	0.12	(0.05)	.799	(0.00)
P4b	0.01	(0.01)	0.06	(0.02)	.005**	(4.22)

Table 2: Comparison of STS and toileting by all participants

^a Student's *t*-test, ^b Wilcoxon Rank Sum test, * Significant differences of $p < .05$, ** Significant differences of $p < .01$, Standard Deviation (SD)

Discussion

Earlier studies have reported that, in hemiplegic stroke patients, standing up induces load asymmetry and COP displacement biased toward the non-paretic side [20,21]. Therefore, these results suggest that the asymmetry of the COP and load would be further increased during toileting because the task of standing up and pulling up pants is a dual task; however, the results were partially different.

This study specifically examined the pulling up of pants in P3 and P4 during the toileting task. That is, P3 of toileting is a phase in which the body moves upward while raising the pants, and P4 involves pulling up the pants in a standing posture, in an adjusting phase. This shows the process of fitting the pants to the body after pulling them up. In general, it is necessary for the COP to move constantly within the range of physical stability in both the AP and ML directions during walking and ADLs [22]. In this study, our STS results were similar to those of earlier studies [20,21]. In the toileting task, P2 and P4 tended to increase the asymmetry of foot force and COP displacement compared to the STS task. However, P3 applied a load to the paretic side during the dual task of raising the pants while standing up. The COP was displaced toward the paretic side. Trunk acceleration is often used as an index of body sway [10,11,12]. This study demonstrated the magnitude of the force applied to the body during the movement. It is apparent that greater force was generated in each direction during toileting than during STS. During toileting in P3, the task of raising the pants while standing up generates a force on the body in the paretic side direction, causing displacement of the COP in the paretic side direction. In addition, stroke shows weakened muscle strength on the paretic side and decreased joint moment [23] and decreased balance ability [24], suggesting significant findings that make it difficult for hemiplegic patients to perform toileting motion.

In this study, the maximum values of the COP, foot force, and acceleration were used for statistical analysis. Hemiplegic stroke patients used three strategies to avoid falling: stepping, pivoting, and hopping [25]. However, failure

of these compensation strategies when the COP deviates from the base of support can lead to falls. Most falls in hemiplegic stroke patients occur during postural changes. Internal factors are often affected by impaired balance, movement, and cognition. The most common places to fall are one's own room or day room, followed by the bathroom/toilet [26]. Falls occur in hemiplegic patients due to a low rate of increase in force when standing up and a large displacement of the COP [20]. Weight training on the Paretic side reduces STS asymmetry, improves COP displacement and speed, and reduces falls [22]. However, improvement in stroke patients' balance occurs independent of the paretic side function and load asymmetry [27]. Clinical occupational therapists and physiotherapists provide guidance for improving lower limb function and balance ability to improve basic movements and prevent falls.

Multiple factors, such as lower limb function, cognitive function, and trunk function are involved in independent toilet activity in hemiplegic stroke patients [2]; thus, improvement in each function is crucial, as in basic movement. However, considering that toileting has different task characteristics from those of STS, occupational therapists and physiotherapists must consider the task characteristics of toilet motion and perform training not only for STS motion but also for the actual toilet motion.

One limitation of this study was that all participants were actually able to go to the toilet independently. In addition, whether the magnitudes of the load on the paretic side of the lower limb, COP displacement, and trunk acceleration are directly related to falls remain unclear. Therefore, additional research is needed, including a comparison between healthy subjects and hemiplegic stroke patients and a comparison between independent and non-independent patients.

Conclusions

The comparison between toileting and STS tasks showed that a force is applied to the body in the posterior direction, ML direction, and upward direction when standing up and pulling up pants, thereby causing a load on the paretic side

and displacement of the COP in the paretic side direction. This finding suggests that differences in task characteristics between STS and Toileting in individuals with hemiplegia who were independent in toileting. Occupational therapists and physiotherapists need to provide independent toileting activity instructions to hemiplegic stroke patients that cover the actual toileting motion in addition to the STS motion.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Author Contributions

HT, YT, and HF conceived and designed the study. HT, YT, NM, KI, HS, ST, and YS participated in data acquisition. HT, NC, and HF analyzed data and wrote the draft of the manuscript. All authors contributed to the article and approved the submitted version.

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