別紙様式１（課程博士申請者用）

博　士　学　位　論　文

論　　文　　題　　名

Analyses of weight-bearing asymmetry pattern for standing in the early phase after stroke: a cross-sectional study

発症早期脳卒中患者における立位の非対称性荷重に関する分析：横断研究

（西暦）　　2023 年　1 月　6 日　提出

東京都立大学大学院

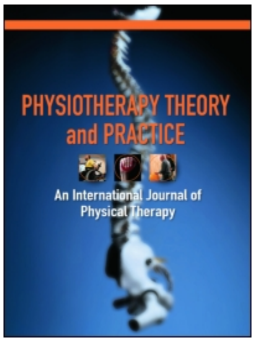
人間健康科学研究科　博士後期課程　人間健康科学専攻

理学療法科学域

学修番号：19995701

氏　名：井上　真秀

（指導教員名：　網本　和）



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Physiotherapy Theory and Practice
An International Journal of Physical Therapy

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/iptp20

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To cite this article: Masahide Inoue, Kazu Amimoto, Yuya Chiba, Daisuke Sekine, Kazuhiro Fukata, Yuji Fujino, Hidetoshi Takahashi & Shigeru Makita (2023): Analyses of weight-bearing asymmetry pattern for standing in the early phase after stroke: a cross-sectional study, Physiotherapy Theory and Practice, DOI: 10.1080/09593985.2022.2163860

To link to this article: https://doi.org/10.1080/09593985.2022.2163860

Published online: 02 Jan 2023.

PHYSIOTHERAPY THEORY AND PRACTICE
https://doi.org/10.1080/09593985.2022.2163860

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REPORT

Analyses of weight-bearing asymmetry pattern for standing in the early phase after stroke: a cross-sectional study

Masahide Inoue[a,b], Kazu Amimoto[b], Yuya Chiba[a], Daisuke Sekine[a,b], Kazuhiro Fukata[a], Yuji Fujino[c], Hidetoshi Takahashi[a], and Shigeru Makita[a]

[a]Department of Rehabilitation, Saitama Medical University International Medical Center, 1397-1 Yamane, Hidaka, Saitama, Japan; [b]Department of Physical Therapy, Tokyo Metropolitan University, 7-2-10 Higashiogu, Arakawa-ku, Tokyo, Japan; [c]Department of Physical Therapy, Juntendo University, 3-2-12, Hongo, Bunkyo-ku, Tokyo, Japan

ABSTRACT

Background: How the weight-bearing asymmetry pattern and related maximum lateral weight-bearing capacity, physical functions, balance, and mobility involved in weight-bearing asymmetry and lesions are related to weight-bearing asymmetry in patients with early-onset stroke remains unclear.
Objective: To investigate the difference between weight-bearing in the early phase after stroke categorized as symmetrical or nonsymmetrical regarding impairments, balance, walking, and independence, and any lesion location difference.
Methods: This cross-sectional study included 46 persons with hemiparetic stroke within 3 weeks from onset undergoing inpatient rehabilitation and classified into symmetrical, paretic, and non-paretic groups. We performed posturographic, functional, mobility, and lesion location assessments on participants once the evaluation was possible.
Results: The symmetrical, paretic, and non-paretic groups included 14, 11, and 21 patients, respectively. The non-paretic group had lesser mean % body weight in maximum lateral weight-bearing to the paretic direction (79% versus 55%, $p < .001$), motor function of the hip lower limb (64 versus 58, $p = .003$) per the Stroke Impairment Assessment Set, Trunk Impairment Scale (18 versus 15, $p = .020$), and Berg Balance Scale (42 versus 32, $p = .047$) than the paretic group with more lesions in the insula (55% versus 0%, $p < .001$) and parietal cortex (36% versus 0%, $p = .009$) than the non-paretic group.
Conclusion: The non-paretic group had low dynamic balance, severe motor paresis, and trunk dysfunction. The paretic group had lesions in the insula or parietal cortex.

ARTICLE HISTORY
Received 7 September 2022
Revised 26 December 2022
Accepted 26 December 2022

KEYWORDS
Stroke; early phase; weight-bearing asymmetry; standing; balance

Introduction

Individuals with stroke frequently report standing balance disorders (Laufer, Sivan, Schwarzmann, and Sprecher, 2003; Tasseel-Ponche, Yelnik, and Bonan, 2015). Approximately 50% of those with anterior brain circulation area damage cannot stand independently 2 months after stroke onset (Laufer, Sivan, Schwarzmann, and Sprecher, 2003). Standing balance recovery may be affected by weight-bearing asymmetry (WBA), reduced lateral weight-shifting capacity, or body sway (Kamphuis, de Kam, Geurts, and Weerdesteyn, 2013; Tasseel-Ponche, Yelnik, and Bonan, 2015). Of these, WBA is one of the common features of static standing posture in individuals with stroke, and many patients show more load on the non-paretic side than on the paretic side (Barra et al., 2009; Genthon et al., 2008; Kamphuis, de Kam, Geurts, and Weerdesteyn, 2013; Tasseel-Ponche, Yelnik, and Bonan, 2015). WBA on the non-paretic side is associated with a decline in functional ability, including reduced postural stability (Kamphuis, de Kam, Geurts, and Weerdesteyn, 2013), longer hospitalization (Sackley, 1991), and reduced independence in performing activities of daily living (ADLs) (Sackley, 1990) and gait performance (Hendrickson et al., 2014).

Contrarily, WBA is not specific to the non-paretic side, as its occurrence has been shown on the paretic side (Mansfield et al., 2013). Moreover, lateropulsion has been reported as a specific postural disorder occurring in the early-to-subacute post-stroke phase, with a postural tilt toward the paretic side being a common feature (Babyar et al, 2019; Dai et al., 2021; Johannsen, Broetz, Naegele, and Karnath, 2006; Karnath, Johannsen, Broetz, and Küker, 2005; Pérennou et al., 2008). Recently, lateropulsion without pushing in subacute stroke has been reported, suggesting that postural

CONTACT Kazu Amimoto amimoto@tmu.ac.jp Department of Physical Therapy, Tokyo Metropolitan University, 7-2-10 Higashiogu, Arakawa-ku, Tokyo 116-8551, Japan

tilt toward the paretic side reduced balance and walking ability in individuals with subacute stroke compared with that in those who could keep their bodies upright (Dai et al., 2021). Therefore, WBA can occur in both the non-paretic and paretic directions in the early phase of stroke, thus affecting balance and walking ability. However, the WBA pattern and its association with dynamic standing balance and mobility after independent standing in the early post-stroke phase are unclear.

WBA toward the non-paretic side is associated with motor dysfunction on the paretic side (Genthon et al., 2008; Roerdink, Geurts, de Haart, and Beek, 2009) revealing that individuals with hemiparesis show an asymmetric posture favoring the non-paretic side. This is to intentionally minimize postural instability caused by the limited participation of the paretic lower limb in postural stabilization during standing in the early-to-subacute post-stroke phase (Genthon et al., 2008). Although factors involved in WBA to the paretic side are unclear, the importance of the cognitive aspects in postural control has been reported (Pérennou et al., 2008). Particularly, lesions in the thalamus (Karnath, Johannsen, Broetz, and Küker, 2005), parietal lobe (Babyar et al, 2019; Pérennou et al., 2008), and insula (Johannsen, Broetz, Naegele, and Karnath, 2006) have been reported to affect postural tilt to the paretic side and are suggested to be involved in gravity perception, also involving the vestibular system (Brandt, Dieterich, and Danek, 1994; Pérennou et al., 2008). However, the effect of motor function and lesion location on WBA to the non-paretic or paretic side in the early post-stroke phase remains unknown. Therefore, we hypothesized that some patients would show general WBA on the non-paretic side even in the early stages, which is a compensatory postural strategy that results from reduced motor function and dynamic balance, including weight-bearing ability in the opposite direction and mobility. Moreover, we hypothesized that some patients who showed WBA toward the paretic side in the early post-stroke stage would have lesions in areas involving spatial cognition such as in the vestibular system. Hence, they would have reduced dynamic balance and mobility, including the ability to shift weight to the non-paretic side and WBA on the non-paretic side. Therefore, this study had two research questions: 1) what is the difference between weight-bearing in the early phase after stroke categorized as symmetrical or nonsymmetrical (toward paretic or non-paretic side) in terms of impairments, balance, walking, and independence; and 2) is there any difference in lesion location? This study aimed to clarify these research questions.

Methods

Study Design and Participants

In this cross-sectional observational study, we enrolled persons with hemiparetic stroke in the early stage after onset who were undergoing inpatient rehabilitation at a university hospital and who met the following criteria: 1) no history of the previous stroke; 2) within 3 weeks from stroke onset; 3) with a supratentorial lesion; 4) right-handed; 5) having lower extremity motor paresis; and 6) being able to stand for >30 seconds without support. A previous study (Bernhardt et al., 2017) described the acute phase as up to 7 days after stroke onset, and the early-to-subacute phase as 7 days to 3 months. The participants in this study were patients whose general condition had stabilized after stroke onset and who were able to stand for 30 seconds. Therefore, we defined the early phase in this study as within 3 weeks of stroke onset. This study was conducted as a secondary analysis using some of the baseline data from a previous study (Inoue et al., 2021). This study was approved by the ethics committee of Saitama Medical University International Medical Center (approval #: 17–154) and Tokyo Metropolitan University (approval #: 18034) and was registered at the University Hospital Medical Information Network Clinical Trials Registry (UMIN-CTR #: UMIN000032088). The participants provided written informed consent before study enrollment according to the Declaration of Helsinki. This study was conducted in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.

Outcome Measures

WBA was evaluated based on posturographic assessments in the static standing position using the SR soft-vision foot pressure version (Sumitomoriko, Komaki, Aichi, Japan). There are 1,024 separate pressure sensors in the SR soft-vision, and it uses a 20-Hz sampling frequency. Participants stood barefoot comfortably with their heels 10 cm apart on the pressure platform during the static standing assessment. A 7-cm^2 observation object was placed 2 m in front of the participant at eye level. Participants were instructed to observe an object while standing still for 30 seconds with both upper extremities attached to the side of the trunk. An adjustment time of approximately 2–3 seconds to stabilize the standing position was allowed before the acquisition time counting began. To evaluate WBA, we calculated the mean percentage body weight (%BW) on the non-paretic side (%). Additionally, the maximum lateral weight-bearing was measured. In this task, the participants were asked to shift their weight in the lateral direction from the static standing position and maintain the posture for 10 seconds. To prevent compensatory movements, the participants were instructed to keep both shoulders parallel to the floor and shift their weight as much as possible without raising the opposite foot. The mean %BW in the moving direction (%; non-paretic or paretic side) during 10-second holds in each direction were calculated. During the posturographic assessment, a physical therapist accompanied the participant to address the risk of falling. The posturographic assessment was performed twice, and the average value was used for analysis. In accordance with a systematic review (Ruhe, Fejer, and Walker, 2010) the posturographic examination of standing tasks with 2–7 assessments were shown to be reliable. Since the participants in this study were stroke patients in the early phase, the measurements were repeated two times for safety and fatigue reasons. The sequence of posturographic assessment was as follows: static standing, maximum lateral weight-bearing to the non-paretic side, maximum lateral weight-bearing to the paretic side, maximum lateral weight-bearing to the paretic side, maximum lateral weight-bearing to the non-paretic side, and static standing. All evaluations for one participant were performed on the same day and took approximately 20 minutes to complete. A 1-minute break was provided if necessary, depending on fatigue. The protocol for the posturographic examination was the same as in a previous study (Inoue et al., 2021).

Functional impairments of stroke were evaluated using the Stroke Impairment Assessment Set (SIAS) (Tsuji et al., 2000). SIAS includes: motor function (i.e. finger function, knee-to-mouth, hip flexion, knee extension, and foot tap); sensory function (i.e. touch and position); tone; range of motion; pain, trunk function; visuospatial function; speech; and unaffected-side function subscales. Each subscale is scored on a 0–3 or 0–5 point scale, with the total score ranging from 0 to 76 and a higher score indicating better function. Truncal balance was estimated using the Trunk Impairment Scale (TIS) (Verheyden et al., 2004). TIS evaluates symmetry and compensation of sitting balance and comprises three subscales: 1) static sitting balance; 2) dynamic sitting balance; and 3) trunk coordination with total scores up to 6, 10, and 7 points, respectively. Higher scores are indicative of better truncal balance. The balance ability was measured using the Berg Balance Scale (BBS) (Berg, Wood-Dauphinee, Williams, and Gayton, 1989). The BBS is an indicator of balance in the sitting and standing positions. It comprises 13 items scored from 0 to 4, with the total score ranging from 0 to 56 and higher scores indicating good balancing ability. The walking ability was estimated using the Functional Ambulation Category (FAC) (Holden et al., 1984). The FAC measures the walking assistance level, regardless of assistive tool use, on a 6-point scale, with higher scores indicating better walking ability. The ADLs concerning motor ability were evaluated using the Functional Independence Measure-motor (FIM-motor) (Linacre et al., 1994). The total FIM-motor score ranges from 13 to 91 with a higher score indicating independence in ADLs.

The lesion location was verified using computed tomography and magnetic resonance imaging. The lesions were assessed in Rolando's frontal, parietal, and temporal cortices and the corona radiata, striatum, internal capsule, and thalamus, according to a previous study (Pérennou et al., 2008). Moreover, we added the insula to our list of locations, which is considered an important site for postural orientation (Johannsen, Broetz, Naegele, and Karnath, 2006). The lesion sites were evaluated by well-trained medical doctors. All outcomes were assessed by individuals who were blinded to the study hypotheses.

Data Analyses

We classified participants into the following groups according to their mean %BW on the non-paretic side during static standing: 1) group with symmetric load (i.e. symmetrical group) which included those with a mean %BW on the non-paretic side between 47% and 53%; 2) group with more load on the paretic side (i.e. paretic group) which included participants with a mean %BW < 47% on the non-paretic side; and 3) group with more load on the non-paretic side (i.e. non-paretic group) which included those with a mean %BW > 53% on the non-paretic side (Mansfield et al., 2013).

To minimize the effect of WBA on the amount of lateral weight-bearing, we determined the differences (⊿) between mean %BW in the moving direction in lateral weight-bearing and mean %BW on the non-paretic side during static standing according to the following equation.

In the case of a non-paretic direction:

⊿N (%) = mean %BW on the non-paretic side in lateral weight-bearing to the non-paretic side – mean %BW on the non-paretic side in static standing

In the case of a paretic direction, the equation was as follows:

⊿P (%) = mean %BW on the non-paretic side in static standing – (100% – mean %BW on the paretic side in lateral weight-bearing to the paretic side)

Continuous and ordinal data are presented as mean (standard deviation). One-way analysis of variance was used for continuous variables to compare overall differences in demographic data. Bonferroni multiple comparison tests were performed to compare the mean differences in impairment, balance, and mobility parameters among the groups. We used z-tests with Bonferroni correction for categorical data to compare risk differences among the groups. Statistical analyses were performed using SPSS version 27.0 (IBM, NY, USA). A p-value < 0.05 was considered significant.

Results

Pattern of Mean %BW on the Non-Paretic Side

We enrolled 46 patients who met the selection criteria and had complete data. There were no missing data among the selected participants. The mean value of mean %BW on the non-paretic side in static standing was 52.9%. Overall, 14 (30.0%), 11 (24.0%), and 21 (46.0%) participants were classified into the symmetrical, paretic, and non-paretic groups, respectively.

Comparison of Patient Demographic and Functional Outcomes among the Three Groups

Table 1 shows the demographic data. There were no differences in patient demographic data among the three groups.

Table 2 shows data of the posturographic assessments, impairments, balance, walking, and independence and the mean differences in the three groups. Regarding the maximum lateral weight-bearing to the paretic direction, the mean %BW on the paretic side was higher in the paretic group than in the non-paretic group ($p < .001$). Conversely, regarding the maximum lateral weight-bearing to the non-paretic direction, there were no significant differences in the mean %BW on the non-paretic side between the groups. However, ⊿N was higher in the paretic group than in the non-paretic group ($p < .001$).

In the impairments outcomes, SIAS-total and knee-to -mouth scores were lower in the non-paretic group than

Table 1. Sociodemographic and clinical characteristics.

	Symmetrical (n = 14)	Paretic (n = 11)	Non-paretic (n = 21)
Sex, male/female	9/5	9/2	13/8
Age, years	68.9 (8.6)	66.8 (5.3)	63.0 (11.4)
Lesion side, right/left	10/4	6/5	8/13
Etiology, infarction/hemorrhage	10/4	6/5	12/9
Height, cm	163.5 (10.5)	164.4 (6.4)	162.4 (7.8)
Weight, kg	64.1 (14.7)	62.2 (9.0)	61.3 (10.7)
Days from stroke onset	12.0 (4.3)	10.3 (4.0)	12.4 (4.7)
Length of hospital stay, days	33.3 (15.6)	23.5 (6.4)	25.1 (7.1)

Continuous data are presented as mean (SD), whereas categorical data are shown as numbers; SD, standard deviation.

Table 2. Mean (SD) for all outcomes in each group and mean difference (95% CI) among the groups.

	Groups			Difference between groups		
	Symmetrical (n = 14)	Paretic (n = 11)	Non-paretic (n = 21)	Symmetrical minus Paretic	Symmetrical minus Non-paretic	Paretic minus Non-paretic
Posturographic assessment						
Static standing Mean %BW on the non-paretic side, %	50 (1)	38 (5)	63 (8)	12 (6 to 17)	−13 (−18 to 8)	−24 (−29 to −19)
Maximum lateral weight-bearing Non-paretic side Mean %BW on the non-paretic side, %	72 (10)	71 (8)	78 (10)	2 (−8 to 11)	-6 (−14 to 2)	-8 (−16 to 1)
⊿N, %	23 (10)	32 (8)	16 (10)	-10 (−20 to 0)	7 (−2 to 15)	17 (8 to 25)
Paretic side Mean %BW on the paretic side, %	70 (10)	79 (8)	55 (19)	-9 (−23 to 5)	15 (3 to 27)	24 (11 to 38)
⊿P, %	20 (10)	18 (10)	17 (14)	2 (−10 to 14)	3 (−8 to 13)	0 (−11 to 11)
Impairments						
Overall SIAS	65 (5)	64 (5)	58 (10)	1 (−7 to 9)	8 (1 to 14)	7 (0 to 14)
SIAS-motor Knee-to-mouth	4.1 (0.6)	3.7 (1.0)	2.8 (1.4)	0.3 (−0.79 to 1.5)	1.3 (0.3 to 2.3)	1.0 (−0.1 to 2.0)
Hip flexion	4.1 (0.4)	4.2 (0.6)	3.1 (1.2)	0.0 (−0.9 to 0.8)	1.1 (0.4 to 1.8)	1.1 (0.3 to 1.9)
Knee extension	4.0 (0.0)	4.0 (0.4)	3.3 (1.3)	0.0 (−1.0 to 1.0)	0.7 (−0.1 to 1.5)	0.7 (−0.2 to 1.6)
Foot tap	3.8 (1.0)	4.1 (0.5)	2.8 (1.5)	-0.3 (−1.5 to 0.9)	1.0 (0.0 to 2.1)	1.3 (0.2 to 2.5)
SIAS-sensory Upper limb	2.6 (0.6)	2.4 (0.7)	2.3 (1.0)	0.2 (−0.6 to 1.0)	0.3 (−0.4 to 1.0)	0.1 (−0.7 to 0.8)
Lower limb	2.6 (0.6)	2.2 (0.8)	2.4 (0.9)	0.4 (−0.4 to 1.2)	0.1 (−0.6 to 0.8)	-0.2 (−1.0 to 0.5)
TIS	19 (2)	18 (3)	15 (4)	1 (−3 to 4)	4 (2 to 7)	4 (0 to 7)
Balance BBS	40 (8)	42 (6)	32 (13)	-2 (−12 to 9)	8 (−1 to 17)	10 (0 to 20)
Walking FAC	2.6 (0.5)	2.7 (0.6)	2.3 (0.7)	-0.2 (−0.8 to 0.5)	0.2 (−0.3 to 0.8)	0.4 (−0.2 to 1.0)
Independence FIM-motor	63 (15	63 (18)	56 (16)	1 (−15 to 17)	7 (−6 to 21)	7 (−8 to 22)

CI, confidence interval; SD, standard deviation; BBS, Berg Balance Scale; BW, body weight; FAC, Functional Ambulation Category; FIM-motor, Functional Independence Measure-motor; SIAS, Stroke Impairment Assessment Set; TIS, Trunk Impairment Scale; Continuous data are presented as mean (SD) or mean difference (95% CI); ⊿N = mean %BW on the non-paretic side in lateral weight-bearing to the non-paretic side − mean %BW on the non-paretic side in static standing; ⊿P = mean %BW on the non-paretic side in static standing − (100% − mean %BW on the paretic side in lateral weight-bearing to the paretic side).

Table 3. Number (%) of lesion locations by group and risk difference (95% CI) among the groups.

	Groups			Difference between groups		
	Symmetrical (n = 14)	Paretic (n = 11)	Non-paretic (n = 21)	Symmetrical minus Paretic	Symmetrical minus Non-paretic	Paretic minus Non-paretic
Roland cortex	2 (14)	1 (9)	0 (0)	5 (−25 to 32)	14 (−4 to 40)	9 (−8 to 38)
Frontal cortex	4 (29)	3 (27)	0 (0)	1 (−33 to 33)	29 (6 to 55)	27 (4 to 57)
Parietal cortex	2 (14)	4 (36)	0 (0)	-22 (−52 to 11)	14 (−4 to 40)	36 (10 to 65)
Temporal cortex	1 (7)	2 (18)	0 (0)	-11 (−41 to 17)	7 (−9 to 32)	18 (−2 to 48)
Insular cortex	3 (21)	6 (55)	0 (0)	-33 (−61 to 4)	21 (1 to 48)	55 (24 to 79)
Corona radiata	7 (50)	6 (55)	16 (76)	-5 (−38 to 31)	-26 (−53 to 5)	-22 (−51 to 11)
Striatum	4 (29)	6 (55)	9 (43)	-26 (−55 to 11)	-14 (−41 to 18)	12 (−22 to 42)
Internal capsule	3 (21)	3 (27)	14 (67)	-6 (−38 to 26)	-45 (−67 to −12)	-39 (−63 to −3)
Thalamus	2 (14)	1 (9)	5 (24)	5 (−25 to 32)	-10 (−33 to 19)	-15 (−37 to 17)

CI, confidence interval; Categorical data are shown as numbers (%); Continuous data are presented as the risk difference (95% CI).

in the symmetrical group (p = .018 and p = .005, respectively), and hip flexion was lower in the non-paretic group than in the symmetrical and paretic groups (p = .002 and p = .003, respectively). Moreover, foot tap was lower in the non-paretic group than in the paretic group (p = .015), and TIS was lower in the non-paretic group than in the symmetrical and paretic groups (p = .001 and p = .020, respectively). Regarding balance, walking, and independence outcomes, the BBS score was higher in the paretic group than in the non-paretic group (p = .047).

Comparison of Lesion Location among the Three Groups

Table 3 shows the number of participants in each group with the specific brain structure that was damaged (% represents the frequency within each group) and risk differences between groups. The z-tests with Bonferroni correction revealed that the non-paretic group had fewer frontal cortex lesions than the other groups (p < .05). Additionally, the paretic group had more lesions in the parietal and insular cortex than the non-paretic group (p < .05), while the non-paretic group had fewer lesions in the insular cortex and internal capsule than the other groups (p < .05).

Discussion

To our knowledge, this is the first study to report the pattern of WBA and difference between weight-bearing categorized as symmetrical or nonsymmetrical in terms of impairments, balance, walking, independence and lesion location in the early post-stroke phase within 3 weeks of onset. Our results revealed that the mean value of mean %BW on the non-paretic side in static standing was 52.9%. Fourteen participants (30.0% of all participants) had paretic asymmetry, 11 (24.0%) had symmetry, and 21 (46.0%) had non-paretic asymmetry. Many previous studies have reported that stroke patients shift their weight more to the non-paretic side than to the paretic side. Barra et al. (2009) revealed that, at 13 weeks from stroke onset, patients loaded 63% of their weight to the non-paretic leg with 19 of 22 patients (86.0%) showing non-paretic asymmetry. Mansfield et al. (2013) showed the following prevalence rates of asymmetric stance in individuals with chronic stroke after 13 months from the onset: paretic asymmetry, 12.0%; non-paretic asymmetry, 48.0%; and symmetry, 40.0%. Furthermore, it has been reported that chronic stroke patients load 42.9% (on average) of their weight on the paretic side, while healthy participants load 48.8% of their weight on the non-dominant side (Mansfield et al., 2011). The percentage of patients with loading to their non-paretic sides was not greater in our study than that reported in previous studies on patients with subacute and chronic stroke. This may have occurred because some participants (paretic group) put more weight on their paretic side than on the non-paretic side, as hypothesized. The inclination to the paretic side has been reported as a characteristic posture in the early-to-subacute stage of stroke onset (Babyar et al, 2019; Abe et al., 2012; D'Aquila et al., 2004; Dai et al., 2021; Johannsen, Broetz, Naegele, and Karnath, 2006; Karnath, Johannsen, Broetz, and Küker, 2005; Pérennou et al., 2008) and the paretic group may reflect those patients in this population who can hold a standing position.

Contrary to our hypothesis, the paretic group had a relatively better ability to shift their weight to the non-paretic side. Additionally, the motor function of the lower limb on the paretic side and trunk function were higher in the paretic group than in the non-paretic group and were equal to those in the symmetry group. Interestingly, the paretic group had more lesions in the parietal and insular cortex than the non-paretic group. These regions are involved in gravity perception and midline localization of the body, causing specific postural disorders such as lateropulsion (Babyar et al, 2019; Johannsen, Broetz, Naegele, and Karnath, 2006; Pérennou et al., 2008). However, the paretic group could hold a standing posture and shift their weight to the non-paretic side. Motor paresis is also involved in lateropulsion (Abe et al., 2012; Johannsen, Broetz, Naegele, and Karnath, 2006). Therefore, in the early stage after stroke, it is suggested that persons with lesions in the insula or parietal lobe but with good motor function may show WBA to the paretic side that allows them to maintain a standing posture.

In this study individuals with WBA on the non-paretic side (non-paretic group) could not bear weight on the paretic side and low BBS score. Additionally, the gradings of the SIAS sub-items (i.e. the hip joint) and TIS on the paretic side were inferior in the non-paretic group compared to those in the symmetrical and paretic groups. The significant relationship between lower limb function on the paretic side and WBA on the non-paretic side supports the findings of a previous study of patients with stroke in other phases (Roerdink, Geurts, de Haart, and Beek, 2009). Furthermore, a report analyzing the relationship between pelvic alignment and trunk control during standing suggested that, with impaired control of the trunk, the pelvis tilts laterally on the extreme paretic side to orient itself toward the non-paretic leg with asymmetrical weight distribution between the feet (Karthikbabu, Chakrapani, Ganesan, and Ellajosyla, 2017). Therefore, the non-paretic group may have shown WBA on the non-paretic side to minimize the postural instability caused by motor paresis in the trunk function and lower limb. The lesions in the non-paretic group showed significantly less damage to the frontal, parietal, and insular cortices than those in the other groups. Considering these findings, it is likely that, while patients in the non-paretic group can perceive their posture correctly, their motor dysfunction is severe, and they employ compensatory strategies to minimize postural instability (Genthon et al., 2008). In this population, rather than correcting postural asymmetry, it might be more appropriate to improve the paretic motor and trunk dysfunction.

This study has some limitations. First, there were no data on healthy controls to compare with our groups. Thus, future studies should consider including healthy age-matched control participants. Second, there were no follow-up data. Hence, the mid- to long-term changes in weight-bearing were unclear. Therefore, the information regarding the improvement of functional disorders, such as motor paresis, and their effects on WBA improvement remains unknown. Further studies should investigate how WBA in the early phase affects clinical outcomes, prognosis, and the quality of daily life in the long term among patients with stroke. Third, the WBA grouping was not based on minimal detectable change (MDC). The MDC of WBA in chronic stroke patients has been reported (Jamal et al., 2022); however, to our knowledge, there are no reports on the MDC of WBA in early-onset stroke patients. In the future, the MDC of WBA in patients with early-onset stroke should be studied. Fourth, this study did not assess the effects of cognitive aspects, such as verticality and visuospatial cognition, on WBA. WBA has been reported to be associated with verticality (Barra et al., 2009) and visuospatial cognition (Embrechts et al., 2021; Genthon et al., 2008). Therefore, it is necessary to investigate verticality and visuospatial cognition to understand WBA in favor of the non-paretic or paretic side. Fifth, we did not evaluate lateropulsion in this study. Future studies should evaluate the lateropulsion using standardized measurements. Finally, we did not consider the effects of the left and right hemispheres. In the future, it will be necessary to separately examine the right and left lesions.

In conclusion, the asymmetric stance on the non-paretic side of patients in the early phase after stroke was less than that in the subacute or chronic phase previously reported. Individuals with paretic asymmetry could bear voluntary weight on their non-paretic side. Individuals with paretic asymmetry had lesions in the insula or parietal lobe but had good motor function. Thus, an approach emphasizing visual or sensory input may be necessary to improve asymmetry. In contrast, individuals with non-paretic asymmetry had a low dynamic balance, such as reduced voluntary weight to the paretic side. In addition, trunk dysfunction and the paretic limb were associated with WBA on the non-paretic side. Therefore, improving paretic and trunk functions could be more helpful than improving asymmetry in patients with non-paretic asymmetry. Thus, if the type of WBA can be known, it will be possible to select training methods accordingly.

Acknowledgments

The authors thank all study participants, as well as our physical therapist for helping with participant assessment. This study was supported by funding for the Hidaka Project (approval number: 30-D-1-16 and 2-D-1-08) of the Saitama Medical University International Medical Center.

Disclosure Statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by the Hidaka Project [30-D-1-16 and 2-D-1-08].

ORCID

Masahide Inoue http://orcid.org/0000-0001-8034-3078
Kazu Amimoto http://orcid.org/0000-0001-5381-4946
Kazuhiro Fukata http://orcid.org/0000-0001-9535-9988

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