

Original Article

Characteristics of the pressure ratio of the gluteal and sole regions during sitting in acute stroke patients using a body pressure distribution measuring system

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ABSTRACT

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Objective: This study investigated the characteristics of sitting balance using a body pressure distribution measuring system in acute stroke patients, together with a comparison of independence and dependence in toileting activities.

Methods: The subjects were 15 men and 15 women ($n=30$, mean age 70 ± 13 years). We divided the subjects into two groups: those who performed their toileting activities independently (independence group, I-group) and those who were dependent in toileting activities (dependence group, D-group). The pressure ratio of the gluteal and sole regions was used as an analysis parameter for comparison between the non-paretic side and paretic side. We evaluated the activities of daily living using the Barthel Index (BI) and the Brunstrom Recovery Stages (BRS).

Results: The difference in the pressure of the non-paretic side and paretic side of the I-group was $4\%\pm 2\%$, and that of the D-group was $19\%\pm 8\%$. The pressures in the I-group were significantly lower than those in the D-group ($p<0.01$). As a standard of the toileting activities in the I-group, the differences between the non-paretic side and paretic side were less than 10%. The BI and BRS scores were significantly better in the D-group ($p<0.01$).

Conclusion: This study was able to visualize the parameter using the pressure ratio of the gluteal and sole regions at the sitting position using a body pressure distribution measuring system for acute stroke patients, and its effectiveness was confirmed. The standard of toileting activities in the independent subjects showed that the differences between the non-paretic side and paretic side were less than 10% for acute stroke patients.

Key words: acute stroke patients, pressure ratio of gluteal and sole region, toileting activity

Introduction

It is important to evaluate activities of daily living (ADL) in acute-phase post-stroke hemiplegic patients for performing occupational therapy. Toileting activities of these patients are an important part of ADL [1–3]. We experienced clinical situations in which patients were unable to perform their toileting activities independently because the body trunk and the neck tilted toward the non-paretic side and the center of gravity deviated to one side when maintaining the sitting position. Occupational therapists evaluate not only motor paralysis, but also trunk functions and the presence or absence of sensory disturbance in the gluteal and sole regions to evaluate the sitting position. They often instruct patients to try and maintain the trunk in the center position using visual compensation tools, such as a mirror. Sadin et al. [4] reported a strong relationship between static and dynamic sitting position balance and the Barthel Index (BI). Okayasu et al. [5] reported differences in the characteristics of the static sitting position between left and right hemiplegia, suggesting their relationship with ADL abilities. However, these studies use gluteal pressure measurements only, without considering the sole pressure. We consider that both the gluteal and sole pressure are related to maintaining the sitting position

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because not only the gluteal, but also the sole pressure is landed.

For this study, gluteal pressure and sole pressure were measured simultaneously using a body pressure measurement system [6] that has recently been introduced in the field of welfare technology as an instrument that can measure the sitting position state over time. In the present study, the system enabled the measurement of an objective index for the upright sitting position in acute stroke patients. Gluteal pressure and sole pressure were measured in the independent group (I-group) and the dependent group (D-group) for toileting activities, which are frequently performed by patients. Furthermore, the relationship with motor function and ADL was investigated. The efficacy of body pressure distribution measurements was also verified based on the obtained results.

These findings are expected to be useful as an index of independence for performing toileting activities in acute stroke patients.

Subjects and Methods

1. Subjects

The study population comprised 30 stroke patients in the early phase of onset among those diagnosed with a stroke and admitted to Hospital A, and for whom occupational therapy was prescribed. Moreover, these 30 met the inclusion criteria: occurrence of the first attack, stable systemic condition, ability to maintain an upright sitting position for 30 s without support from the arms, ability to understand instructions, and no other orthopedic disease.

The subjects were 15 men and 15 women, with a mean age of 70±13 years. Twenty-one patients had

cerebral infarction, 7 had cerebral hemorrhage, and 2 had subarachnoid hemorrhage. There were 14 right hemiplegic patients and 16 left hemiplegic patients. Measurements were conducted 33±15 days after onset. Subjects had no remarkable sensory disturbance or higher brain dysfunction. The ethics committee of Hospital A approved this study. Candidates received verbal and written explanations before they provided consent to participate in this study.

2. Methods

The subjects were classified into the toileting I-group (those who did not need assistance involving body contact, such as assistance in maintaining a standing position or assistance with lower garments, including the monitoring level) and the D-group (those who needed assistance involving body contact). The subjects were classified in advance with a toileting activity evaluation using BI [7], an index of ADL.

The sitting pressure distribution was measured using a body pressure measurement system (BPMS; NATT, Osaka). The subjects were instructed to maintain the upright sitting position for 30 s on the device with sensor mats placed under the buttocks and the feet. The height of the upright sitting position was set so that the subject would have 90° of flexion at the knee and hip joints and the whole sole would be in contact with the foot mat (Figure 1-a). Placement of any object or person that marked the centerline in the surroundings was carefully avoided. The subjects were instructed to place their arms on the ipsilateral femoral region to the greatest extent possible, or, if that was difficult, at a position in which it was possible to maintain the upright sitting position. The sitting pressure at the four locations of the left and right

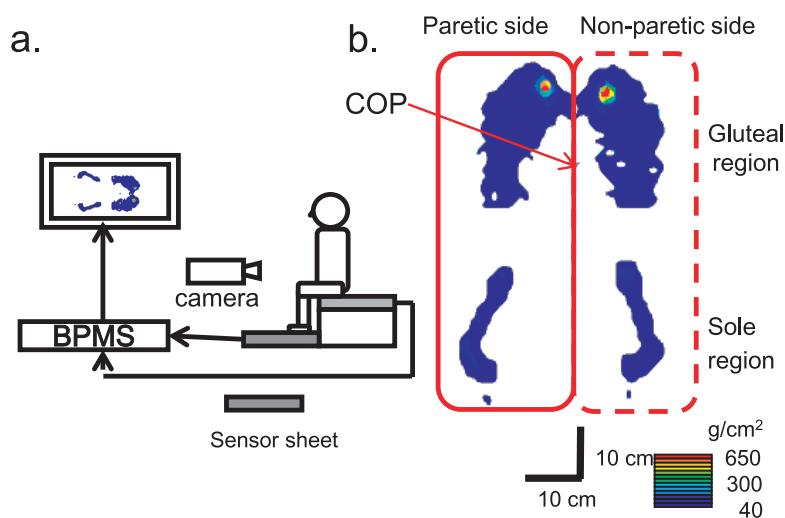


Figure 1. Measuring equipment and pressure distribution analysis.
 a. Experimental setup
 b. Analysis parameter of gluteal region pressure and sole region pressure
 COP, Center of pressure.
 BPMS, Body pressure distribution measurement system.

gluteal muscles and the soles is shown as a percentage (%) and was configured so that the sum would be 100% (Figure 1-b). In this study, the sum of the gluteal pressure and sole pressure was analyzed as the sitting pressure. The center of the left and right anterior superior iliac spine was adjusted to the center of the sensor mat as the standard for the center of the gluteal muscle. An image of the still sitting position (front) was taken using a digital video camera (GZ-E265, JVC; Kenwood Corp., Yokohama). Motor function was evaluated using the Brunnstrom Recovery Stages (BRS) [8], and ADL was evaluated using the BI score.

Statistical analyses were performed to make comparisons between the I-group and the D-group using Welch's *t*-test for age, time from onset, sitting pressure percentage and BI score; the Mann-Whitney *U*-test was used for the upper extremities, fingers, and lower extremities for BRS. Additionally, software (Excel for Windows; Microsoft Corp. and Bell Curve for Excel; SSRI) was used with significance inferred at 5%.

Results

Based on the results of the toileting activity evaluation using BI scores, 12 and 18 subjects were classified into the I-group and D-group, respectively. The BRS for the upper extremities, fingers, and lower extremities were significantly higher in the I-group (*p*<0.01). No significant difference was found for the other investigated parameters (Table 1).

A representative sample of the I-group was a 60-year-old woman with right hemiplegia. Her BRS was V for upper extremities, V for fingers, and IV for lower extremities; toileting was at the independence level. Her BI score was 80. Her gluteal and sole pressure percentages were 43% and 8%, respectively, on the non-paretic side, and 40% and 9%, respectively, on the paretic side (Figure 2).

The representative sample of the D-group was a 70-year-old man with right hemiplegia. His BRS was IV for upper extremities, IV for fingers, and IV for lower extremities. He was able to perform toileting

activities with partial assistance. His BI score was 40. The gluteal and sole pressure percentages were 50% and 11%, respectively, on the non-paretic side and 31% and 9%, respectively, on the paretic side (Figure 3).

Sitting pressure (sum of gluteal and sole pressure) percentages on the non-paretic side of all the subjects were 46%–53% in the I-group. The mean difference in the percentage between the non-paretic side and the paretic side was 4%±2%. However, it was 38%–68% in the D-group. The mean difference in the sitting pressure was 19%±8%. The measurement for the I-group was significantly lower than that for the D-group (*p*<0.01). Among the 18 subjects of the D-group, 14 subjects deviated to the non-paretic side, whereas 4 subjects deviated to the paretic side. In addition, the difference in the sitting pressure between the non-paretic and paretic side was within 10% for all subjects of the I-group (Figure 4, 5).

The BI scores of all the subjects ranged from 60–100 in the I-group, with a mean value of 80±16. The score was 10–60 in the toileting D-group, with a mean

- 60-year-old woman, cerebral infarction, right hemiplegia
- BRS U/E stage V, Finger stage V L/E stage V; BI: 80
- Difference of 2% in the pressure of the non-paretic side and paretic side

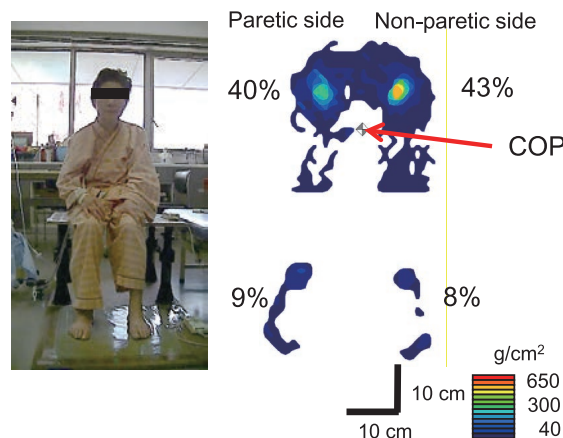


Figure 2. Case of toileting activities classified as independent (A).

Table 1. Characteristics of the subjects.

	I-group (n = 12)	D-group (n = 18)	<i>p</i>
Age (y)	69±13	71±1	N.S.
Period from onset (d)	29±14	35±15	N.S.
U/E	4 (3–5)	2 (1–5)	**
BRS Finger	4 (3–5)	2 (1–5)	**
L/E	4 (4–5)	2 (1–5)	**

I-group, Independence group; D-group, Dependence group; BRS, Brunnstrom Recovery Stage; U/E, Upper Extremities; L/E, Lower Extremities.

Data is the mean ± SD or median (max – min).

N.S.: Not Significant **:*p*<0.01

- 70-year-old man, cerebral infarction, right hemiplegia
- BRS U/E stage IV, Finger stage IV, L/E stage IV; BI: 40
- Difference of 22% in the pressure of the non-parietic side and parietic side

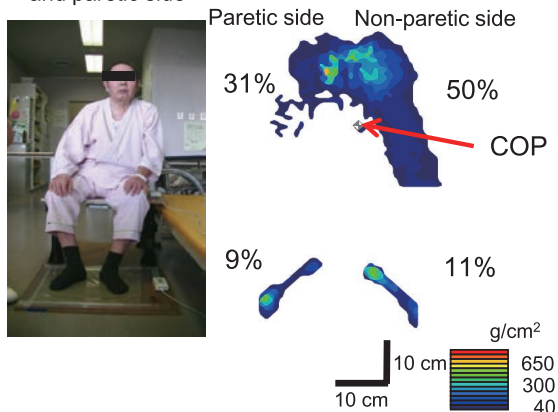


Figure 3. Case of toileting activities classified as dependent (B).

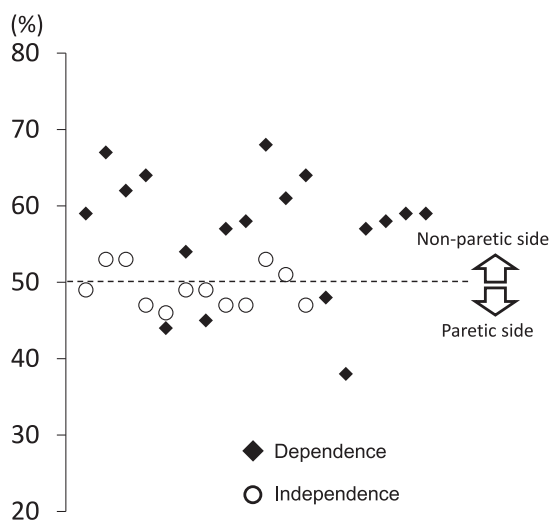


Figure 4. Pressure distribution rate of all the subjects.

of 41 ± 15 . It was significantly higher in the I-group than in the D-group ($p < 0.01$) (Figure 6).

Discussion

This study aimed to elucidate the characteristics of gluteal pressure and sole pressure in the upright sitting position in acute stroke patients with hemiplegia classified according to independence in performing toileting activities into the I-group and D-group. We also assessed the relationship with motor function and ADL and the efficacy of body pressure distribution measurement.

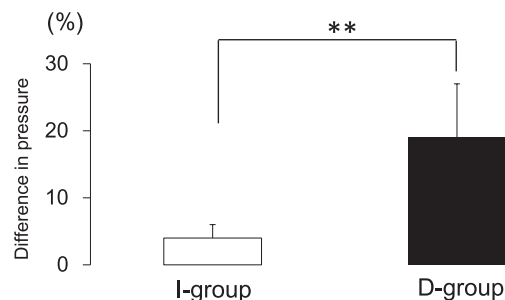


Figure 5. Comparison between the I-group and D-group for the difference in pressure of the non-paralytic and paralytic side.

Welch *t*-test **: $p < 0.01$

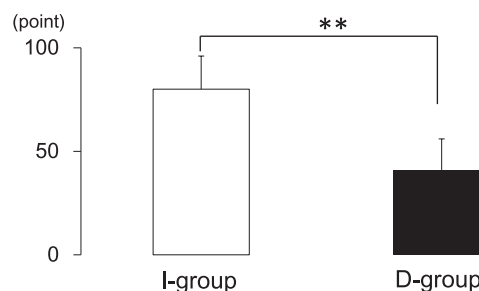


Figure 6. Comparison between the I-group and D-group for BI.

Welch *t*-test **: $p < 0.01$

1. Gluteal pressure and sole pressure in the upright sitting position of the I-group and the D-group classified according to independence in performing toilet activities, and the relationship with motor function and ADL

The present results revealed that differences in the sitting pressure between the non-parietic and parietic side were $4\% \pm 2\%$ and $19\% \pm 8\%$, respectively, in the I-group and the D-group. The differences were significantly lower in the I-group. Moreover, as a standard for the I-group, the difference in the sitting pressure between the non-parietic and parietic side was within 10%. The BI scores of the I-group and D-group were 80 ± 16 and 41 ± 8 , respectively, significantly higher in the I-group. All the BRS scores for the upper extremities, fingers, and lower extremities were significantly higher in the I-group.

For acute stroke hemiplegic patients, it is necessary to acquire ADL at an early stage in addition to getting out of bed and avoiding disuse. Tokumoto et al. reported that greater improvement in ADL was observed in acute stroke patients due to the involvement of occupational therapists in the early phase [9, 10]. Furthermore, Ezure et al. reported that the ADL of post-stroke hemiplegic patients was more strongly related to trunk function than to the functions of the parietic side [11]. In particular, toileting activities include going to the toilet, transferring to and operating

the toilet seat, handling the lower garments, urination and defecation, and subsequent cleaning up. These require balance control for various changes in position [3]. This study specifically assessed the relationship of the upright sitting position with BRS and BI scores, especially toileting activities, which are particularly important. The results demonstrate that BRS scores for the upper extremities, fingers, and lower extremities were at least stage IV, and that the BI score was at least 60 in the I-group. These results are useful as the criteria for independence in performing toileting activities. Granger et al. [12] reported that a total BI score of over 60 in stroke patients was the appropriate criterion for home discharge. This finding agrees with the score for independence in toileting activities, suggesting that independence in performing toileting activities, which patients frequently need to perform, can be an indicator for home discharge.

2. Efficacy of body pressure distribution measurement in ADL

For this study, we were able to measure changes in the pressure distribution using the body pressure measurement system. The percentage of the pressure on the non-paretic side in the toileting I-group was 46%–53%, with a mean of $4\% \pm 2\%$, suggesting that the sitting pressures of the paretic and non-paretic side were approximately equal. To our knowledge, no other studies include such observations. Generally, ADL includes many activities conducted in the sitting position, such as eating and toileting activities. In acute-phase situations, the trunk tilts toward the paretic or non-paretic side in the sitting position. When the sitting position is asymmetrical, assistance is necessary in many situations to prevent falls, especially while performing toileting. These results confirmed that ADL situations, including toileting activities, are affected by maintaining pressure distribution in the sitting position that is equal between the paretic and non-paretic side. In future studies, we plan to investigate the change in the sitting position over time and the percentage of sole pressure in the standing position, as well as the relationship with ADL in

addition to toileting activities.

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