

Original Article

Effects of the wheelchair sitting posture on gluteal pressure

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Abstract. [Purpose] To evaluate the efficacy of the “forward-tilting posture” (the trunk tilted forward against a table) in a wheelchair in relieving gluteal pressure. [Participants and Methods] Thirty-six healthy adults were instructed to sit in a wheelchair assuming the following three postures: (1) both feet placed on the foot support with the trunk upright (“basic sitting posture”), (2) both feet placed on the foot support with the trunk tilted forward against a table (“forward-tilting posture A”), and (3) both feet placed on the floor with the trunk tilted forward against a table (“forward-tilting posture B”). A seat-type sensor pad placed on a wheelchair cushion was used to measure the maximum gluteal pressure and gluteal contact area. [Results] The maximum gluteal pressures in “forward-tilting postures A” and “forward-tilting postures B” were significantly lower than those in the basic sitting posture. The maximum gluteal pressure in “forward-tilting posture B” was significantly lower than that in “forward-tilting posture A”. The gluteal contact area in “forward-tilting posture B” was significantly larger than that in “forward-tilting posture A”. [Conclusion] The study results indicate that the “forward-tilting posture” in a wheelchair effectively relieves gluteal pressure.

Key words: Wheelchair, Sitting posture, Pressure relief

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INTRODUCTION

A pressure ulcer is a localized injury to the skin and underlying tissue, usually over a bony prominence, resulting from sustained pressure, including pressure associated with shear¹⁾. Sitting for long periods without frequent repositioning can lead to pressure ulcer development in older, frail, immobile, or neurologically impaired individuals²⁾. Patients in care facilities often sit in wheelchairs with a poor seated posture for long periods of the day³⁾, which increases their risk of developing pressure ulcers on the buttocks^{4, 5)}. Thus, the contact pressure of the buttocks against the seat (“gluteal pressure”) should be considered to prevent pressure ulcers among older adults who spend long periods sitting in wheelchairs. Repositioning is the mainstay of most pressure ulcer prevention methods⁶⁾. To prevent pressure ulcers, wheelchair users should maintain proper posture and postural control¹⁾.

In the sitting position, the majority of the body mass is transmitted through the pelvis to the buttocks and onto the seat’s surface, consequently making the pelvis the most important load-bearing site⁷⁾. The sacral sitting posture, which is characterized by a posterior pelvic tilt and lumbar kyphosis⁸⁾, increases the gluteal contact pressure⁹⁾. Previous studies have also suggested that backrest angles¹⁰⁾, seat inclination¹¹⁾, sitting postures (erect sitting, slouched posture with cross-legged sitting, and erect posture with cross-legged sitting)¹²⁾, wheelchair foot support height^{13, 14)}, the use of a lumbar support¹⁵⁾, the use of wheelchair cushions made with firm material to support the thighs¹⁶⁾, and wheelchair seat cushions types^{17, 18)} affect the gluteal pressure distribution. However, as a standardized method of measuring posture and pressure distribution simultaneously has not yet been developed, the mechanism by which posture affects pressure distribution has not been fully elucidated. Clinically effective pressure-relieving techniques should be developed taking this situation into account.

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Studies on patients with spinal cord injury have reported that the forward-leaning posture in which the trunk is sufficiently tilted forward in a wheelchair, effectively relieves the pressure on the ischial tuberosity^{19, 20}. However, the hip must be sufficiently flexed to tilt the trunk forward, thereby making forward-leaning difficult in older people with limited hip joint motion. Moreover, wheelchair foot support is less stable than the floor, and it prevents users from shifting their weight forward in the wheelchair²¹. Because of the structural instability of the foot support, older adults in wheelchairs may be prevented from tilting their trunk forward, shifting the center of gravity forward, and thus adopting a forward-leaning posture. The “forward-tilting posture” (the trunk tilted forward against a table) is recommended as a variation of the forward-leaning posture to tilt the trunk forward in a wheelchair²² (Fig. 1). Older adults with a limited range of hip flexion can maintain a “forward-tilting posture” because the forward trunk inclination angle is relatively small. The stability of a desk that supports the body compensates for foot instability and allows older people to tilt their trunks and shift their weight forward. The “forward-tilting posture” could be a suitable technique for relieving gluteal pressure that can be used by older adults in wheelchairs.

The posture required to relieve gluteal pressure in a wheelchair can be easily maintained by older people with limited physical function so that they can benefit from decompression. This study aimed to evaluate the efficacy of the “forward-tilting posture” in relieving gluteal pressure.

PARTICIPANTS AND METHODS

Thirty-six healthy adults (10 males, 26 females; mean age, 21.0 ± 0.7 years) participated in this study. Their mean lower leg length (the length of the lower leg from the back of the knee to the bottom of the heel)²³ was 40.1 ± 2.6 cm. Measurements were performed using a standard manual wheelchair (AR-101/111; Matsunaga manufactory Co., Ltd., Gifu, Japan). A wheelchair cushion (type 5 TC-045; Takano Heartworks Co., Ltd., Nagoya, Japan) was placed on the seat. The wheelchair’s seat surface-to-foot support distance and seat surface-to-floor distance were adjusted to the lower leg length of each participant. The thickness of the wheelchair cushion was 40 mm, and the front seat height of the wheelchair AR-101 was 430 mm, while that of the wheelchair AR-111 was 380 mm. In this study, the height of the seat surface was measured by adding the thickness of the cushion and the front seat height of each of the wheelchairs’ seats; therefore, the height was 470 mm ($430 \text{ mm} + 40 \text{ mm}$) and 420 mm ($380 \text{ mm} + 40 \text{ mm}$) for the AR-101 and AR-111, respectively. The foot support heights were adjusted by using the foot support height adjustment function of each wheelchair. The height of the floor surface was adjusted by stacking any number of wooden boards with a thickness of 10 mm. Before measuring the gluteal pressure in the wheelchairs, the seating leg length of the participants was measured in 1-cm increments and the wheelchair’s seat surface-to-foot support distance and seat surface-to-floor distance were adjusted. The participants with a seating leg length of ≤ 420 mm used the wheelchair AR-111, and those with a seating leg length of ≥ 430 mm used the wheelchair AR-101. A research article on table heights used by older adults reported that the standard height of tables used by elderly wheelchair users was 750 mm²⁴. Therefore, in this study, the table height was set to 750 mm when using the wheelchair AR-101, and to 700 mm when using the wheelchair AR-111, taking into consideration the fact that the front seat height was 50 mm lower than that of the AR-101.

The participants assumed three postures: (1) both feet placed on foot support with the trunk upright (“basic sitting posture”), (2) both feet placed on foot support with the trunk tilted forward against a table (“forward-tilting posture A”), and (3) both feet placed on the floor with the trunk tilted forward against a table (“forward-tilting posture B”) (Fig. 2).

When measuring the “basic sitting posture”, participants were instructed to sit on the wheelchair with their buttocks moved toward the back of the seat and their trunk in an upright position. When measuring “forward-tilting posture A” and “forward-tilting posture B”, participants were instructed to sit on the wheelchair with their buttocks moved toward the back of the seat, tilt forward against a table, place their hands together in the most comfortable position possible, place their head on top of them, and relax.



Fig. 1. Participant in forward-tilting posture.

The participants randomly assumed three postures to exclude the effects of the measurement order on the measured values. For each posture, the maximum gluteal pressure and gluteal contact areas were measured.

An SR Soft Vision sensor pad (Fukoku Bussan Co., Ltd., Tokyo, Japan) placed on the wheelchair cushion was used to measure the maximum gluteal pressure and gluteal contact areas. The SR Soft Vision is a seat-type sensor pad with 256 pressure sensing points, indicating the loaded pressure at each point. The amount of responding sensing points was considered to be the size of the contact area.

For the maximum gluteal pressures and contact areas measured in the three different measurement postures, the Friedman test was used to test differences in median measurements after the Shapiro–Wilk test for distribution measurements. The statistical significance was set at $p < 0.05$. For multiple comparisons, the Wilcoxon signed-rank sum test was used, with the significance level modified by Bonferroni correction. All analyses were performed using the Japanese version of Statistical Package of Social Sciences version 24.

The Medical Ethics Committee of Tohoku Fukushi University approved this study (RS190503), and written informed consent was obtained from all participants.

RESULTS

Table 1 shows the maximum gluteal pressures and contact areas measured in “basic sitting posture”, “forward-tilting posture A”, and “forward-tilting posture B”.

The median values of the maximum gluteal pressure in “forward-tilting posture A” and “forward-tilting posture B” were 94.0 (interquartile range [IQR]: 23.5) and 80.5 (IQR: 20.3) mmHg, respectively, which were significantly lower than that in “basic sitting posture” (110.5 [IQR: 31.0]) ($p < 0.001$). The median value of the maximum gluteal pressure in “forward-tilting posture B” was significantly lower than that in “forward-tilting posture A” ($p < 0.001$).

The gluteal contact areas in the “basic sitting posture” and “forward-tilting posture A” were 154.5 (IQR: 41.3) and 158.5 (IQR: 35.5) points, respectively, and the two values did not differ significantly from each other. In contrast, the median value of the gluteal contact area in “forward-tilting posture B” was 175.0 (IQR: 35.0) points, which was significantly larger than that in the “basic sitting posture” ($p < 0.001$). The median value of the gluteal contact area in “forward-tilting posture B” was significantly higher than that in “forward-tilting posture A” ($p < 0.001$).

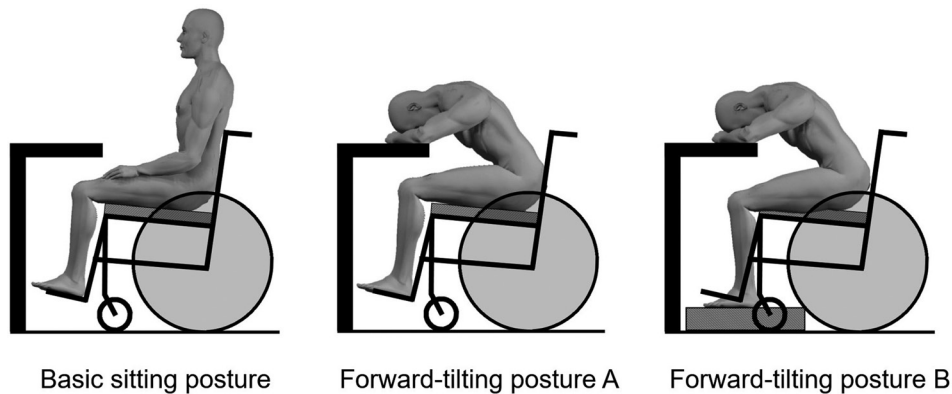


Fig. 2. “Basic sitting posture”, “Forward-tilting posture A”, and “Forward-tilting posture B”.

The participants assumed three postures: (1) both feet placed on foot support with the trunk upright (“basic sitting posture”), (2) both feet placed on foot support with the trunk tilted forward against a table (“forward-tilting posture A”), and (3) both feet placed on the floor with the trunk tilted forward against a table (“forward-tilting posture B”).

Table 1. Measurement values during three postures (n=36)

| | Basic sitting posture | Forward-tilting posture A | Forward-tilting posture B |
|---------------------------------|------------------------------|-----------------------------|------------------------------|
| Maximum contact pressure (mmHg) | 110.5 (31.0) ^{a, b} | 94.0 (23.5) ^{a, c} | 80.5 (20.3) ^{b, c} |
| Size of contact area (point) | 154.5 (41.3) ^a | 158.5 (35.5) ^b | 175.0 (35.0) ^{a, b} |

Results are expressed as the median (the interquartile range).

^{a-c} Pairs of letters indicate significant difference between postures; the Friedman test and Bonferroni post hoc test ($p < 0.05$).

DISCUSSION

The study results indicate that the “forward-tilting posture (the trunk tilted forward against a table)” in a wheelchair is effective for relieving gluteal pressure. Previous studies have reported that a forward-leaning posture (the trunk is sufficiently tilted forward in a wheelchair) relieves contact pressure on the ischium tuberosity^{19, 20}. The “forward-tilting posture” was hypothesized to be as effective as the forward-leaning posture.

Body weight dictates gravitational forces that act downward and are responsible for body pressures; however, how well they are distributed is a function of posture⁷. In the “forward-tilting posture”, participants tilted their trunks forward and shifted their center of gravity forward. This posture change presumably reduced gluteal pressure and weight in the buttocks. In this study, “forward-tilting posture B” (both feet placed on the floor with the trunk tilted forward against a table) was associated with the largest gluteal contact area and lowest maximum gluteal pressure. In “forward-tilting posture B”, participants placed their feet on a stable floor. Therefore, they were able to put enough weight on their feet and shift their weight forward. The increased weight on the feet and the forward-shifted center of gravity allowed participants to distribute their weight over a larger area, including the posterior thighs, rather than just the gluteal region. The weight distribution on the buttocks over a larger body area in contact with the wheelchair seat is considered to account for the greatest decrease in the maximum pressure.

Comparing “forward-tilting posture A” (both feet placed on a foot support with the trunk tilted forward against a table) and “forward-tilting posture B” (both feet placed on the floor with the trunk tilted forward against a table), lower maximum gluteal pressure and larger gluteal contact area were measured in “forward-tilting posture B”. Foot support positioning is related to the pressure on the seat interface of the wheelchair¹³. Lowering the feet in the wheelchair transfers some leg weight from the feet to the foot support or the floor. A previous study reported that lowering the foot support reduced pressure on the ischial tuberosities¹⁶. A foot support that is too high raises the thigh of the seat surface, which flexes the hip and reduces the contact area at the buttocks, resulting in elevated pressures on the buttock tissue⁷. These studies indicate that the height of the feet, which corresponds to the height of the foot support, influences gluteal pressure. In “forward-tilting posture B”, the participants’ feet were positioned on the floor. Their feet were positioned lower than those in “forward-tilting posture A” in which both feet were placed on foot support. “Forward-tilting postural B” with the foot height lower supposedly effectively expands the gluteal contact area and reduces gluteal pressure.

Previous studies on pressure ulcers in older adults in wheelchairs have focused on seat cushion types and pressure distributions, demonstrating their effects on pressure ulcer prevention and development^{17, 18}. However, these studies revealed that the sitting posture of older participants has not been adequately examined. Future studies should focus on the sitting posture of older adults in wheelchairs and show that changes in sitting posture are effective in relieving gluteal pressure; they should also demonstrate the effects of altered sitting posture on the prevention and development of pressure ulcers.

This study has some limitations. This study was conducted on healthy adults; thus, the findings cannot be generalized to older adults in wheelchairs. The efficacy of the “forward-tilting posture” as a posture to relieve gluteal pressure should be investigated in future studies on older adults in wheelchairs. In this study, only the leg length in a sitting position was measured as a physical characteristic of participants, which limits the generalizability of the study’s findings. Furthermore, this study focused only on the peak pressure and the size of the contact area of the buttocks against the seat. Detailed analyses of pressure distribution, such as the anterior and posterior parts, would provide a more comprehensive understanding of the obtained data.

In this study, the maximum gluteal pressure and contact area in “forward-tilting posture (the trunk tilted forward against a table)” and in “basic sitting posture (both feet placed on a foot support with the trunk upright)” were measured and compared. The study results indicate that the “forward-tilting posture” in a wheelchair effectively relieves gluteal pressure.

A similar study should be conducted on older adults in wheelchairs to verify the validity of these results.

Conference presentation

Part of this study result was presented at the 18th World Federation of Occupational Therapists Congress²⁵.

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Conflict of interest

There are no conflicts of interest to declare.

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