



Original Article

Effects on sitting pressure distribution during the application of different cushions and anterior height wedges

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Abstract. [Purpose] The purpose of this study was to investigate interface pressure redistribution in healthy volunteers when applying different cushions and anterior wedge heights. [Subjects and Methods] This study included 36 healthy individuals in their 20s. The peak and mean pressures were measured by applying different cushions and anterior wedge heights. The results were analyzed by using a one-way analysis of variance and post-hoc analysis. [Results] The peak and mean pressures were statistically significant based on the cushion types and anterior wedge height. The peak pressure was at its highest and lowest when sitting on a 6-cm anterior wedge and a foam cushion, respectively. The mean pressure was greatest when sitting on a 6-cm anterior wedge of a firm surface and smallest when sitting on a 5 cm foam cushion. [Conclusion] This study shows that the most effective method for pressure redistribution was sitting on a 5 cm foam cushion without an anterior wedge.

Key words: Anterior wedge, Cushion, Interface pressure

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INTRODUCTION

Pressure ulcers are a common and debilitating health care condition¹⁾. When a body part is under pressure, tissue cells do not receive nutrients properly, thereby resulting in their death and the appearance of a lesion. In addition to exposure to pressure, an elevated body temperature and a high skin humidity may also contribute to pressure ulcer formation, which appears as an irritation in the upper layers of the skin and may reach muscles and bone tissue²⁾. Pressure ulcers are harmful to subjects, particularly those who have additional risk factors related to poor health³⁾. In this sense, small injuries have large implications in the quality of life of disabled people. Therefore, it is important to prevent pressure ulcers.

The correlation between being seated and the presence of pressure ulcers has been reported frequently since epidemiological studies of pressure ulcers were first conducted⁴⁾. Barbenelet et al. reported the pressure ulcer prevalence survey in the United Kingdom and noted that chair-bound patients consistently exhibited a higher frequency of developing pressure sores compared with bed-bound patients with a similar degree of helplessness⁵⁾. Other surveys have also shown this association between being seated and the presence of pressure ulcers^{6, 7)}.

The guidelines concerning pressure ulcers issued by the National Institute for Health and Care Excellence (NICE) in the United Kingdom include a statement regarding seating, in which the authors stressed the need for qualified assessment of seating needs, the importance of correct eating positions, and the need to maintain posture and support the feet when using a wheelchair⁸⁾. In people who are at risk for pressure ulcers or in those with bedsores, pressure redistribution must be tended to such that no pressure is applied to the pressure ulcer⁹⁾. A number of management strategies, including a number of com-

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mercially available alternating pressure cushions and wedges, can provide pressure redistribution^{10, 11}).

Lee reported the effectiveness of cushions and an anterior wedge sitting position in pressure ulcers. In their study, they showed that the type of cushion and appropriate height wedges made a statistically significant difference in sitting pressure¹². Several studies found a correlation between cushion types and sitting pressure or between anterior wedge height and sitting pressure. However, pressure redistribution when cushions and wedges are applied simultaneously has not been investigated.

Consequently, the purpose of this study was to analyze user–cushion interface pressure redistribution when different cushion types and height anterior wedges are applied simultaneously for healthy volunteers.

SUBJECTS AND METHODS

This study was approved by the Institutional Review Board of Soonchunhyang University. This study was a pilot study to direct future research, to perform adult norm pressure mapping.

This study included 21 female and 15 male volunteers. The participants were between 20 and 27 ± 1.6 years of age. All participants were identified as able-bodied subjects, and the procedure was fully explained to them. The participants consisted of healthy young adults living in South Korea. The exclusion criteria included any type of sitting problems, or hearing, visual, or cognitive impairments that interfere with accurate participant assessments. Written informed consent was obtained from all subjects before starting measurements. The subjects were informed that they could withdraw from the study at any stage for whatever reason. Participant characteristics are provided in Table 1.

The ConFORMAT system and research software V.7.2 were used for pressure mapping and data acquisition, respectively. One occupational therapist and three university students collected the pressure data while the participants were sitting on a firm surface without a cushion, a 5-cm height gel cushion, a 5-cm height memory foam cushion, a 3-cm anterior wedge without cushion, a 3-cm anterior wedge with a 5-cm height gel cushion, a 3-cm anterior wedge with a 5-cm height memory foam cushion, a 6-cm anterior wedge without cushion, a 6-cm anterior wedge with a 5-cm height gel cushion, and a 6-cm anterior wedge with a 5-cm height memory foam cushion. The participants were instructed to keep their chins tucked in, spines straight, hands on their thighs, and pelvis neutrally positioned when sitting on the cushions. They were initially instructed to flex their hips, knees, and ankles at approximately 90° and to put their feet flat on the floor. Each joint angle and sitting position were checked for each measurement. And then cushions and wedges were instructed. After measurement, the pressure map was divided into four quadrants on screen graphics, with each quadrant representing the left hip, left thigh, right hip, and right thigh. For the quadrant division, the Mergl method was adapted and used to analyze the sitting pressure on the cushion. The mean and peak pressures for each quadrant were analyzed. The peak pressure was the mean of the maximum pressures measured with four sensors in each quadrant. The mean pressure was the mean of the pressures measured with every sensors in each quadrant.

SPSS version 22.0 was used for statistical analysis. The participant characteristics were tested by descriptive statistical analysis, and results were tested by a one-way analysis of variance and post-hoc analysis.

RESULTS

General demographic information, including age, weight, height, and sitting position, is shown in Table 1. In both genders, the mean and peak pressures were the lowest when sitting on a 5-cm foam cushion. The mean pressure in the hip and thigh was the highest on a 6-cm wedge and on a firm surface, respectively. The mean pressure was observed to increase in the following order: a foam cushion, a 3-cm anterior wedge with a 5-cm foam cushion, a 6-cm anterior wedge with a 5-cm foam cushion, a 5-cm gel cushion, a 3-cm anterior wedge with a 5-cm gel cushion, a 6-cm anterior wedge with a 5-cm gel cushion, a 3-cm anterior wedge without cushion, without cushion, and a 6-cm anterior wedge without cushion (Tables 2 and 3).

Table 1. General characteristics of the subjects

	Male (N=15)	Female (N=21)
Age (years)	21.7 ± 2.0	20.1 ± 0.5
Weight (kg)	66.1 ± 8.7	53.9 ± 9.2
Height (cm)	171.8 ± 6.2	158.4 ± 5.1
Seat to footplate (cm)	46.7 ± 5.3	43.8 ± 4.6
Seat depth (cm)	49.5 ± 3.5	45.9 ± 4.9
Seat width (cm)	36.0 ± 3.4	34.3 ± 3.6
Hip (°)	99.9 ± 5.5	99.5 ± 7.2
Knee (°)	93.9 ± 5.9	99.5 ± 6.8
Ankle (°)	93.4 ± 5.7	97.3 ± 6.3

DISCUSSION

Prolonged mechanical loading can lead to breakdown of the skin and underlying tissues, which can, in turn, develop into a pressure ulcer¹³. It may be caused by inadequate blood supply and resulting reperfusion injury when blood re-enters the tissue. When sitting in the same position for extended periods, the dull ache experienced is indicative of impeded blood flow to affected areas. The shortage of blood supply may lead to tissue damage and cell death within 2 h¹⁴. One of the assessment factors relating to the prevention of pressure sores is the pressure of cushions on clients¹⁵.

The benefits of pressure relief and/or redistribution in minimizing pressure-related health risk (including of pressure ulcer), among other issues, have been well documented. One such strategy has been performed by using support cushions or wedges¹⁰. However, few studies have offered information on the combination effects of cushions with anterior wedges. Hence, the objective of this study was to evaluate pressure redistribution effects on the user–cushion interface pressure of healthy volunteers in their 20s when applying different cushions, including a firm surface with and without different height anterior wedges.

Our results show that the mean and peak pressures were greatest when sitting without a cushion with 3-cm and 6-cm anterior wedges and without anterior wedge compared with the other sitting arrangements. The mean pressure in the hip was the highest when sitting on a 6-cm anterior wedge without a cushion, whereas the mean pressure in the thigh was the highest when sitting on a firm surface without an anterior wedge. In addition, the mean and peak pressures were the lowest when sitting on a foam cushion without an anterior wedge. Gong and An reported that the mean and peak pressures were the lowest when a 6-cm anterior wedge was used. However, in this study, these two variables were the lowest when sitting on a foam cushion without an anterior wedge¹¹. This discrepancy may be the result of differences in the initial sitting position. The participants of this study sit with the hip, knee, and ankle joint at an angle of more than 90°. Therefore, the sitting professional must assess posture before recommending the use of cushions and wedges.

From the results, we presumed that the foam cushion could be the best choice for pressure redistribution. These results suggest that people who sit, particularly those with diseases, seek out professional support in choosing the appropriate cushion and height of their chair based on their needs.

The present study only compared the performance of two cushions, including a firm surface, and two types of anterior wedges, in redistributing user–cushion interface pressures with limited participants. Hence, the number of participants, cushions, and wedge types, as well as the height of the cushion and wedges, must be expanded for generalization in future studies. In addition, since the sitting position could be the main factor for user–cushion interface pressure redistribution, the relationship between sitting positions and interface pressure redistribution must be investigated. As the proper cushion types and anterior height wedges for people with or without diseases, such as stroke, spinal cord injury, and muscular dystrophy, must be established, this study establishes important guidelines for future research for establishing a sitting environment.

Table 2. Peak pressure distribution according to wedge height and cushion type (N=36, mmHg)

	Firm surface	5 cm Gel cushion	5 cm Foam cushion	3 cm Wedge	5 cm Gel cushion with 3 cm Wedge	5 cm Foam cushion with 3 cm Wedge	6 cm Wedge	5 cm Gel cushion with 6 cm Wedge	5 cm Foam cushion with 6 cm Wedge
RHPP*	304.43 ± 95.46	123.04 ± 71.21	116.09 ± 69.57	308.64 ± 91.46	131.88 ± 55.87	122.25 ± 67.42	346.25 ± 91.69	158.92 ± 55.58	168.22 ± 43.09
RTPP*	62.83 ± 19.93	52.49 ± 17.79	43.85 ± 24.28	77.73 ± 29.57	57.01 ± 21.39	48.19 ± 18.15	85.52 ± 39.89	66.28 ± 25.94	65.20 ± 27.81
LHPP*	305.89 ± 85.11	120.03 ± 40.14	127.96 ± 42.27	321.21 ± 88.04	130.64 ± 57.14	130.03 ± 92.82	321.91 ± 94.82	146.31 ± 65.99	166.83 ± 88.00
LTPP*	71.47 ± 25.24	54.61 ± 24.81	41.93 ± 17.05	67.99 ± 37.98	58.01 ± 24.61	43.75 ± 17.47	92.15 ± 38.37	57.52 ± 25.07	61.00 ± 21.22

R/LHPP: right/left hip pressure peak pressure; R/LTPP: right/left thigh pressure peak, *p<0.05

Table 3. Mean pressure distribution according to wedge height and cushion type (N=36, mmHg)

	Firm surface	5 cm Gel cushion	5 cm Foam cushion	3 cm Wedge	5 cm Gel cushion with 3 cm Wedge	5 cm Foam cushion with 3 cm Wedge	6 cm Wedge	5 cm Gel cushion with 6 cm Wedge	5 cm Foam cushion with 6 cm Wedge
TPM*	59.09 ± 10.29	37.86 ± 9.24	29.45 ± 9.30	57.00 ± 11.49	39.14 ± 6.50	29.60 ± 6.43	60.45 ± 10.04	41.70 ± 7.13	30.92 ± 8.52
RHPM*	85.04 ± 17.62	49.76 ± 15.39	39.41 ± 13.04	84.55 ± 19.64	54.74 ± 14.05	41.80 ± 12.72	88.61 ± 18.30	67.02 ± 48.03	42.65 ± 15.67
RTPM*	31.88 ± 11.73	25.45 ± 12.41	17.78 ± 7.11	27.04 ± 9.85	24.93 ± 6.68	18.81 ± 5.56	29.26 ± 9.32	25.31 ± 7.58	22.59 ± 19.51
LHPM*	85.86 ± 16.43	49.53 ± 16.41	42.53 ± 18.72	87.96 ± 17.49	67.39 ± 6.08	42.58 ± 16.92	88.68 ± 17.02	58.01 ± 17.45	45.83 ± 17.91
LTPM*	30.84 ± 11.13	25.92 ± 8.12	18.19 ± 6.92	27.07 ± 9.34	26.61 ± 6.72	19.15 ± 5.81	29.06 ± 9.65	26.43 ± 7.90	27.71 ± 8.02

TPM: total pressure mean; R/LHPM: right/left hip pressure mean; R/LHPP: right/left hip pressure peak, *p<0.05

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