



Original Article

Effects of different seat cushions on interface pressure distribution: a pilot study

SANG-HEON LEE, OT, PhD¹⁾, JI-SU PARK, OT, BSc^{2)*}, BONG-KEUN JUNG, OTR, OTD¹⁾,
SUNG-A LEE, OT, PhD¹⁾

¹⁾ Department of Occupational Therapy, College of Medical Science, Soonchunhyang University, Republic of Korea

²⁾ Department of Occupational Therapy, Soonchunhyang University Graduate School: Soonchunhyang-ro 22, Shinchang-myeon, Asan-si, Republic of Korea

Abstract. [Purpose] The purpose of this study was to evaluate pressure redistribution on the supporting area of healthy volunteers when using different cushions. [Subjects and Methods] Twenty healthy individuals ranging in age from 19–23 years old and 20 older adults age 60 or above participated in the study. All participants lived in urban communities in South Korea. Group differences according to gender, age, and cushion types were analyzed with one-way analysis of variance and post-hoc analysis. [Results] Statistically significant differences in peak pressure and mean pressure were identified between age, gender, and cushion types. Peak pressure and mean pressure were higher on firm surfaces and on the air cushion than other cushion types. The pressure ratio was lower when an air cushion was used in the buttock area and was higher when it was used under the thighs compared to that in other conditions. [Conclusion] This study showed that interface pressure can be distributed differently depending on what cushions are used. Therefore, when using seat cushions, individuals should seek advice to help them choose the appropriate cushion for their needs.

Key words: Cushion, Seating pressure, Pressure ulcer

(This article was submitted Sep. 1, 2015, and was accepted Oct. 16, 2015)

INTRODUCTION

Pressure ulcers, also known as decubitus ulcers or bedsores, are defined as localized tissue breakdown in the skin and adjacent tissue caused by prolonged high pressure and mechanical forces over the bony prominences^{1–4)}. The most common sites are the skin overlying the sacrum, coccyx, heels, or the hips, but other sites such as the elbows, knees, ankles, or the back of the cranium can be affected. These external forces may reduce or interrupt the blood flow within the skin, thus affecting not only the transport of nutrients into the cells but also causing ischemia associated with a decrease in tissue oxygenation which could eventually lead to tissue necrosis^{5–7)}. Pressure ulcers are hazardous, particularly for individuals with additional risk factors related to poor health⁸⁾. In this sense, even small injuries have large implications on the quality of life of disabled people; therefore, preventing pressure ulcers is very important.

Pressure redistribution is important for people at risk for pressure ulcers and those with bedsores so that no pressure is applied to the pressure ulcer⁹⁾. The benefits of some form of pressure relief and/or redistribution have been well established for many groups deemed to be at high risk of developing pressure ulcers. This can be provided by a number of management strategies ranging from regular turning of the patient, which is labor intensive, to active support surfaces including a number of commercial alternating pressure cushions¹⁰⁾.

Several static support surfaces have been developed in order to alleviate pressure beneath the ischial tuberosities^{1, 11)}. This has led to the design of a wide variety of wheelchair cushions that are commercially available. Some of them are composed

*Corresponding author. Ji-Su Park (E-mail: titi518@hanmail.net)

©2016 The Society of Physical Therapy Science. Published by IPEC Inc.

This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial No Derivatives (by-nc-nd) License <<http://creativecommons.org/licenses/by-nc-nd/3.0/>>.

of viscoelastic materials such as foam, gels, air, or a combination of all of them. In South Korea, foam, gels, and air cushions are widely used. However, the pressure redistribution effect of these cushions has not been investigated in South Korea. Users depend on health professionals to help choose their cushions, but these health professionals do not have access to sufficient research to recommend appropriate cushion types, materials, height, etc.

Consequently, the purpose of this study was to evaluate the pressure distribution effects on the supporting area when healthy volunteers used different cushions, then to provide objective evidence for selecting proper cushion types. This study addresses our hypothesis that interface pressure on the seating area can be redistributed with different cushions.

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 in the field of normal adult pressure mapping and special support system development. All participants provided informed consent before participating in the study. The participants were consisted of healthy young adults and older adults living in South Korea. Exclusion criteria included any type of sitting problems or hearing, vision, or cognitive impairments that would interfere with accurate assessment of the participants.

Twenty females and 20 males volunteered to participate in this study. The participants were between 19 and 80 years old. All participants were able-bodied subjects, and the procedure was fully explained to them. Written consent was obtained from the subjects before starting the measurements. The subjects were informed that they could withdraw from the study at any stage for any reason. Further information about participant characteristics is provided in [Table 1](#).

All participants were assessed at the Community Welfare Center and Participation Science Laboratory of Soonchunhyang University. The ConFORMAT system was used for pressure mapping, and the research software V.7.2 × was used for data acquisition. These system and software were manufactured by Teckscan Inc. located at Massachusetts, USA. One occupational therapist and three university students collected pressure data while subjects were sitting on a firm surface without a cushion, with a 5 cm high gel cushion, a 7 cm high air cushion, and a 5 cm high memory foam cushion. When sitting on the cushions, the participants were asked to keep their chins tucked, spines straight, hands on their thighs, and pelvis neutrally positioned. They were also asked to flex their hips, knees, and ankles about 90 degrees and to put their feet flat on the floor. For every measurement, each joint angle and seating position was checked. After all measurements were taken, the pressure map was divided into four quadrants (left hip, left thigh, right hip, and right thigh) on the screen. Mergl's method was adapted for quadrant division and analysis of pressure on the cushion ([Fig. 1](#))¹⁰. The mean pressure, peak pressure, and mean pressure ratio for each quadrant were analyzed. The mean pressure ratio was calculated by dividing the mean pressure of one quadrant by the mean pressure of the hip and thigh on that side.

SPSS version 22.0 (IBM Corporation, New York, USA) was used for statistical analysis. The differences between the groups were tested by one-way analysis of variance and post hoc analysis. Levene's test was used to analyze the equality of variances.

RESULTS

General demographical information including age, sex, and education is shown in [Table 1](#). Statistically significant differences were identified between the following three values ($p < 0.05$): the right hip pressure ratio and the left thigh pressure ratio on a memory foam cushion, and the right thigh pressure ratio when sitting on a firm surface without a cushion. For all ages, mean pressure value and peak pressure were higher when on a firm surface without a cushion and on an air cushion compared to other conditions. On an air cushion, the pressure ratio was lower in the hip but higher in the thighs than the other

Table 1. General characteristics of the subjects

	Young adults		Old adults	
	Male (N=10)	Female (N=10)	Male (N=10)	Male (N=10)
Age (years)	20.9±1.7*	18.9±0.3	76.6±4.2	76.4±1.2
Weight (kg)	68.5±8.7	55.0±6.8	65.7±7.2	54.0±8.4
Height (cm)	173.3±5.9	155.7±5.0	164.2±3.1	147.6±5.3
Seat to footplate (cm)	45.1±5.1	37.6±2.0	40.2±1.8	36.0±1.9
Seat depth (cm)	54.0±2.9	49.0±6.3	44.2±3.2	43.0±4.1
Seat width (cm)	35.2±1.0	39.4±1.7	37.8±2.1	33.5±3.3
Hip (°)	97.2±2.1	95.4±6.9	97.5±7.3	94.9±6.8
Knee (°)	92.2±3.7	90.9±4.9	98.2±5.8	98.9±5.0
Ankle (°)	90.4±2.6	93.0±5.4	92.4±4.4	93.5±5.0

* Mean±standard deviation

conditions. The pressure ratio in the hip was the highest on a firm surface, then on the memory foam cushion, gel cushion, and air cushion in descending order. This order was reversed in the thighs.

DISCUSSION

Prolonged mechanical loading can lead to breakdown of skin and underlying tissues, which can, in turn, develop into a pressure ulcer¹²⁾. This breakdown may be caused by inadequate blood supply and a resulting reperfusion injury when blood re-enters the tissue. The dull ache experienced while sitting in the same position for extended periods is indicative of impeded blood flow to the affected areas. Within 2 hours, this shortage of blood supply may lead to tissue damage and cell death. The sore will start as a red, painful area.

The benefits of pressure relief and/or redistribution to minimize risk have been well documented, and these benefits can be provided by support cushions¹⁰⁾. However, few studies have offered comparative information on the mechanical characteristics of different wheelchair seat cushions. The objective of the present study was to compare the mechanical benefits and interface pressure distribution of the different wheelchair seat cushions most frequently used in South Korea.

A statistically significant difference was found in the right hip pressure ratio and the left thigh pressure ratio when on a memory foam cushion, and the right thigh pressure ratio while sitting on a firm surface without a cushion may indicate differences in individual seating patterns. Some people tend to lean either to the right or to the left and may lean more on either the hip or the thigh. We found that both the mean pressure and the peak pressure were higher when sitting on a firm surface without a cushion and when on an air cushion compared to other conditions in all ages, and these were lower when on a gel cushion or an air cushion. The pressure ratio was lower in the hip and higher in the thighs when on an air cushion than in the other conditions. The higher peak pressure on the air cushion compared to the other conditions shows the importance of controlling the air pressure level in the air columns, the distance between the columns, and the properties of the material. The pressure ratio in the hip was the highest when on a firm surface, then on a memory foam cushion, gel cushion, and air cushion, in descending order. These results reveal that air cushions could be the best choice for pressure redistribution. Persons who sit on cushions, especially individuals at higher risk for pressure ulcers, should ask for professional support in choosing the appropriate cushion for their needs.

In future studies, the number of participants, age groups, and cushion types must be increased to generalize these results. The present study only compared the interface pressures of four cushions with limited participants and age groups. In addition, the relationship between general patient characteristics and the effects of several factors on the interface pressure, including seat depth, seat inclination, back support angle, and sitting patterns, need to be investigated. In addition, the proper air pressure level and the height of the air columns for each age group and for individuals with diseases such as stroke, spinal cord injury, and muscular dystrophy must be evaluated. These may be the most important guidelines when selecting an air cushion. None of the other points of interests in cushion selection was evaluated without interface pressure distribution. In some cases, features such as stability, ease of transfer, moisture control, or maintenance needs may be more important than small differences in support pressure when selecting a wheelchair cushion¹³⁾.

ACKNOWLEDGEMENT

This work was supported by the Soonchunhyang University Research Fund and the Ministry of Science, ICT and Future Planning, Korea, under the Convergence Information Technology Research Center (IITP-2015-IITP-2015-H8601-15-1009) supervised by the Institute for Information & Communications Technology Promotion.

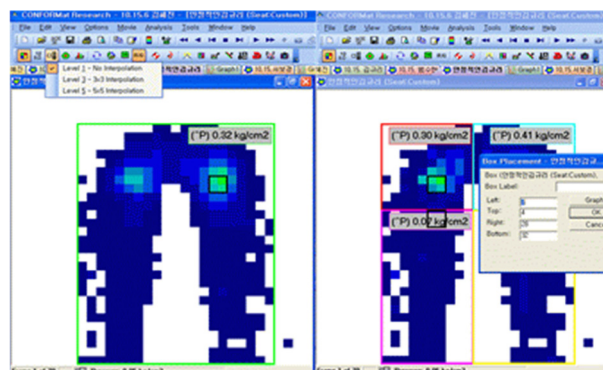


Fig. 1. Four quadrants of interface pressure analysis

REFERENCES

- 1) Bar CA: Evaluation of cushions using dynamic pressure measurement. *Prosthet Orthot Int*, 1991, 15: 232–240. [[Medline](#)]
- 2) Thomas DR: Prevention and treatment of pressure ulcers. *J Am Med Dir Assoc*, 2006, 7: 46–59. [[Medline](#)] [[CrossRef](#)]
- 3) Gil-Agudo A, De la Peña-González A, Del Ama-Espinosa A, et al.: Comparative study of pressure distribution at the user-cushion interface with different cushions in a population with spinal cord injury. *Clin Biomech (Bristol, Avon)*, 2009, 24: 558–563. [[Medline](#)] [[CrossRef](#)]
- 4) Matsuo J, Sugama J, Sanada H, et al.: Development and validity of a new model for assessing pressure redistribution properties of support surfaces. *J Tissue Viability*, 2011, 20: 55–66. [[Medline](#)] [[CrossRef](#)]
- 5) Nakagami G, Sanada H, Sugama J: Development and evaluation of a self-regulating alternating pressure air cushion. *Disabil Rehabil Assist Technol*, 2015, 10: 165–169. [[Medline](#)] [[CrossRef](#)]
- 6) Barnett RI, Ablarde JA: Skin vascular reaction to short durations of normal seating. *Arch Phys Med Rehabil*, 1995, 76: 533–540. [[Medline](#)] [[CrossRef](#)]
- 7) Jan YK, Jones MA, Rabadi MH, et al.: Effect of wheelchair tilt-in-space and recline angles on skin perfusion over the ischial tuberosity in people with spinal cord injury. *Arch Phys Med Rehabil*, 2010, 91: 1758–1764. [[Medline](#)] [[CrossRef](#)]
- 8) Mayrovitz HN, Smith J: Heel-skin microvascular blood perfusion responses to sustained pressure loading and unloading. *Microcirculation*, 1998, 5: 227–233. [[Medline](#)] [[CrossRef](#)]
- 9) Reilly EF, Karakousis GC, Schrag SP et al.: Pressure ulcers in the intensive care unit: the ‘forgotten’ enemy. *OPUS 12 Scientist*, 2007, 1(2): 17–30.
- 10) Chai CY, Bader DL: The physiological response of skin tissues to alternating support pressures in able-bodied subjects. *J Mech Behav Biomed Mater*, 2013, 28: 427–435. [[Medline](#)] [[CrossRef](#)]
- 11) Stockton L, Rithalia S: Pressure-reducing cushions: perceptions of comfort from the wheelchair users’ perspective using interface pressure, temperature and humidity measurements. *J Tissue Viability*, 2009, 18: 28–35. [[Medline](#)] [[CrossRef](#)]
- 12) Mergl C, Klendauer M, Mangen C, et al.: Predicting long term riding comfort in cars by contact forces between human and seat. *SAE International*, 2005, pp1–21.
- 13) Burns SP, Betz KL, Betz KL: Seating pressures with conventional and dynamic wheelchair cushions in tetraplegia. *Arch Phys Med Rehabil*, 1999, 80: 566–571. [[Medline](#)] [[CrossRef](#)]