J. Phys. Ther. Sci. 29: 57–63, 2017

The Journal of Physical Therapy Science

Original Article

Comparing the interface pressure redistribution of three different types of cushions: differences according to age groups and cushion preferences

Ji-Su Park, OT, MS[1)], Sang-Heon Lee, OT, PhD[2)*]

[1)] *Mapo Welfare Center, Republic of Korea*
[2)] *Department of Occupational Therapy, College of Medical Science, Soonchunhyang University: 22 Soonchunhyang-ro, Sinchang-myeon, Asan-si, Chungcheongnam-do 31538, Republic of Korea*

Abstract. [Purpose] The purpose of this study was to analyze the change in interface pressure redistribution of three different types of cushions sat on by individuals in their 20s and older than 60 years old. [Subjects and Methods] One hundred and eleven college students and 100 persons than 60 years old were recruited. Sitting pressure redistribution was measured while subjects sat without cushions or on honeycomb, air, and memory foam cushions in that order. Subsequently, the cushion preference was measured. After obtaining all measurements, the mean total pressure and each quadrant's mean and peak pressure were analyzed. [Results] The mean hip and the peak pressures were low in the group of females aged 60 years or older, and the highest in the group of males in their 20s. The hip pressure ratio was low in the groups of females in their 20s and 60 years or older, whereas the thigh pressure ratio was high in the same groups. The analysis of cushion preference showed that the groups of males (42.0%) and females (40.0%) in their 20s mostly preferred air cushion. The men (55.1%) and women (50.0%) aged 20 years or older selected honeycomb and air cushions as the first and third preferred cushions with a high response rate. [Conclusion] Our results indicate that gender and age should be considered when recommending appropriate pressure redistribution cushions.

Key words: Cushions, Pressure mapping, Interface pressure redistribution

(This article was submitted Aug. 24, 2016, and was accepted Sep. 26, 2016)

INTRODUCTION

Pressure ulcers are localized injuries of the skin and underlying tissue due to capillary circulation disturbance caused by prolonged pressure[1)], and are usually located over bony prominences. Pressure ulcers should be managed because they are difficult to treat once they have developed, and the treatment can be expensive due to the increased length of hospitalization and pressure ulcers can lead to complications, such as osteomyelitis and sepsis, in addition to pain.

The causes of pressure ulcers are classified into extrinsic and intrinsic factors. Extrinsic factors include direct pressure, pressure duration, shear, friction, temperature, and moisture; and intrinsic factors include motor deficits, sensory deficits, muscular atrophy, health and nutritional status, decreased tissue perfusion, and aging.

Those who are susceptible to pressure ulcers owing to intrinsic factors include individuals with stroke, brain injury, spinal cord injury, circulatory disturbance, elimination disorder, poor nutrition, and geriatric disease. Based on studies of pressure ulcer incidences among adults, Song et al. and Park et al. reported that the pressure ulcer incidence in residents at long-term care facilities in South Korea was 9.8% and 5.2%[2, 3)], respectively. In older adults, the epidermis is thinning because of the loss of subcutaneous fat that distributes the weight of the body, the skin is susceptible to dryness due to decreased sweat and sebaceous gland activities, and the skin is susceptible to damage: and recovery from injury is prolonged because of

*Corresponding author. Sang-Heon Lee (E-mail: sangheon@sch.ac.kr)

Table 1. General information of subjects

	Elderly men (N=50)	Elderly women (N=50)	Young men (N=49)	Young women (N=62)
Age* (years)	78.2 ± 5.8**	74.6 ± 4.9	19.7 ± 1.4	19.6 ± 1.1
Weight* (kg)	64.3 ± 8.6	57.9 ± 10.0	69.1 ± 10.5	57.1 ± 7.8
Height* (cm)	159.8 ± 21.3	150.7 ± 4.8	173.8 ± 5.6	158.9 ± 4.5
Seat to footplate* (cm)	40.1 ± 2.2	36.0 ± 1.6	44.0 ± 3.1	39.0 ± 3.0
Seat depth* (cm)	40.9 ± 4.2	42.7 ± 3.7	54.2 ± 3.4	45.8 ± 5.0
Seat width* (cm)	39.3 ± 3.4	34.4 ± 3.7	36.0 ± 4.2	38.4 ± 3.3
Total contact area* (cm^2)	661.7 ± 197.7	728.1 ± 182.1	829.5 ± 162.9	813.0 ± 135.2
Hip (°)	93.4 ± 7.6	92.4 ± 8.1	98.5 ± 3.9	95.1 ± 6.2
Knee (°)	97.0 ± 5.9	97.0 ± 6.0	91.8 ± 3.7	90.7 ± 4.9
Ankle (°)	91.7 ± 5.1	93.0 ± 4.4	89.9 ± 3.4	91.2 ± 4.3

*p<0.05, **Mean ± SD

gradually decreasing replacement and proliferation of epidermal cells[4]. Furthermore, because older adults have two or more chronic degenerative diseases on average, and the majority of older adults have limited mobility due to cerebrovascular and musculoskeletal diseases, hence, they are vulnerable to pressure ulcers, which require prevention and management.

Cushions have been designed for pressure ulcer prevention to relieve interface pressure in the sitting position. Although existing cushions are mainly rubber products that are filled with air, products using special materials, such as gel and foam, and those with a combination of gel-air, gel-foam, or foam-air, have become commercially available in recent years[5]. Moreover, the long-term care insurance scheme in South Korea entitles beneficiaries to certain assistive products or partially compensates and beneficiaries for fees paid to medical device, and cushions for preventing pressure ulcers are also covered by this insurance scheme. With regard to the use of assistive technology by rehabilitation workers at nursing facilities, the proportion of those who use cushions for preventing pressure ulcers was reported to be 68.2%, and posture and sitting assistive equipment have been identified as essential among assistive technology devices that will be needed in the future[6]. Continuous and proper positioning (or continuously adjusting individual posture) to promote blood circulation in an area where pressure is concentrated, minimizing pressure in a localized area, such as the buttocks, and distributing pressure more evenly throughout a contact surface are important interventions to prevent pressure ulcers. Proper sitting posture and application of devices designed to maintain appropriate sitting posture are also important as assistive technological approaches to distributing pressure across areas where pressure is concentrated[7]. The cushions used for preventing pressure ulcers reduce the peak sitting pressure over bony prominences and distribute pressure equally to the skin over a large contact area; and shear force that inhibits circulation can be also reduced by using appropriately made cushions.

In South Korea, a long-term care insurance scheme for the elderly covers 20 types of cushion for pressure ulcer prevention, among which, air cushion type is the most common type. In the case of air cushions, the pressure distribution effect is excellent, but its dynamic stability is poor. The dynamic stability of products using gel and foam is excellent, but the pressure gradient, which is slightly high, is a disadvantage[8].

Most previous studies have enrolled healthy adults and persons with disability, but studies of older adults are scarce. Large-scale studies are needed to generalize the outcomes. Furthermore, because no study has investigated the effects of honeycomb cushions covered by South Korea's long-term care insurance on sitting pressure redistribution, there is limited information for recommending an appropriate cushion types. The purpose of this study was to analyze the change in the sitting pressure redistribution of three different types of pressure ulcer prevention cushions, honeycomb, air, and memory foam cushions, used byseniors older than 60 years old and adults in their 20s.

SUBJECTS AND METHODS

The present study was approved by the Institutional Review Board of Soonchunhyang University. The purpose of the present study was explained to all of subjects, and their informed consent was obtained before they participated in the present study. The participants consisted of 49 males in their 20s, 62 females in their 20s, 50 elderly males 60 years or older, and 50 elderly females 60 years or older who had no neurological disease, were able to sit by themselves, and had sufficient visual acuity, hearing, and cognitive function to answer general questions (Table 1).

The ConFORMAT system was used for pressure mapping, and V.7.2 ×research software was used for data acquisition (both ConFORMAT and V7.2 ×were manufactured by Tecksan Inc., MA, USA). The 1024 CONFOR TMat sensors are thin and flexible. The horizontal axis has 32 sensors numbered 1 to 32, and the vertical axis has 32 sensors labeled A to FF (32 × 32) . The sitting pressure was measured in mmHg, and at a sampling rate of 1 Hz. The ConFORMAT was placed on each cushion during data acquisition, and one occupational therapist and two university students collected the pressure data. After

Table 2. Comparisons of the total pressure mean among groups (N=211, mmHg)

		Without cushion		Honeycomb cushion		Air cushion		Memory foam cushion	
		Mean ± SD	Tukey HSD	Mean ± SD	Tukey HSD	Mean ± SD	Tukey HSD	Mean ± SD	Tukey HSD
TPM	A	47.5 ± 7.0	C>A,B,D	37.6 ± 4.5	C>A,B,D	48.2 ± 14.6	C>A,B,D	30.1 ± 3.0	C>A,B,D
	B	47.8 ± 6.6		35.2 ± 5.9		45.5 ± 5.4		27.5 ± 3.1	
	C	56.3 ± 12.9		42.3 ± 9.2		55.0 ± 11.0		34.9 ± 8.1	
	D	48.6 ± 12.0		36.6 ± 10.7		47.4 ± 10.0		29.6 ± 7.2	

TPM: total pressure mean, A: male (60 years and older), B: female (60 years and older), C: male in their 20s, D: female in their 20s

the participants' height and weight had been measured, the participants adjusted their posture in a sitting position using a footstool. While sitting on the cushions, participants were instructed to keep their chins tucked in, spines straight, pelvis neutrally positioned, and place their hands placed on their thighs. They were also instructed to flex their hips, knees, and ankles to approximately 90°, and to put their feet flat on the floor. The sitting position and each joint angle were checked before each measurement.

Height, weight, foot height, and seat height (seat to footplate), width (seat width), length (seat depth), total contact area (total contact area), hip joint, knee angle, and ankle joint were measured in the sitting position. The posture was readjusted within joint range of motion (ROM) of 85°–95°, knee–ankle ROM of 80°–100°, and hip joint ROM of 80°–110° based on the angles from the no-cushion state. When each cushion was changed, the subjects' posture was readjusted to avoid an angular difference of more than 10° in each ROM. After the subjects' general information has been recorded, sitting pressure-related variables were measured. The subjects were instructed to maintain their sitting state for 5 min, and the researchers saved the data for 90 s after the subjects' sitting posture had stabilized. The cushions were wrapped in black cloth after the measurements, and the subjects were instructed to sit on the wrapped cushions in the following order: honeycomb, air, and memory foam cushions. Each cushion was referred to as sitting states 1, 2, 3, and 4. Thus the subjects were informed of only the changes of the cushions and were provided with no information regarding the specific cushions. After all measurements has been conducted, the cushion preference was surveyed by instructing the subjects to select the most preferred sitting state.

After all measurements had been recorded, 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[9]. A set of 60 frames were used for data analysis, excluding the data of 10 s each at the beginning and end from the obtained data to exclude environmental factors which might have affected the measurements.

After the sitting pressures had been measured, the mean and peak pressures in four quadrants (left hip/left thigh/right hip/right thigh) were calculated. The peak pressure was determined as the mean of the maximum pressures measured by the four sensors in each quadrant during sitting. The mean pressure was the mean of the pressures measured by each sensor on each quadrant. The mean pressure ratio was calculated as A ratio=A mean/(A mean + B mean + C mean + D mean) ×100. The ratio indicate the mean pressure ratio, and the mean can be the mean pressure on the right or left hip area or the right or left thigh area, and B mean, C mean, and D mean are the mean pressures of the remaining areas, respectively.

The Statistical Package for the Social Sciences 20.0 was used for statistical analyses. One-way analysis of variance was condected to determine the significance of differences between groups, and Tukey's post-hoc test was performed ($p<0.05$). The cushion preference was analyzed through cross analysis.

RESULTS

The males in their 20s showed significantly high pressures in all sitting positions when the mean total pressure values were compared (Table 2).

Significant differences were found in the right hip pressure mean, right hip pressure peak, left hip pressure peak, right hip pressure ratio, and left hip pressure ratio while sitting without a cushion ($p<0.05$) (Table 3). Significant differences were found in the right hip pressure mean, left hip pressure mean, right hip pressure peak, left hip pressure peak, right hip pressure ratio, and left hip pressure ratio of age groups on the honeycomb cushion ($p<0.05$). Significant differences were found in the left hip pressure peak of age subjects on the air cushion ($p<0.05$). Significant differences were also found in the right hip pressure mean, left hip pressure mean, right hip pressure peak, left hip pressure peak, and left hip pressure ratio between subjects on the memory foam cushion ($p<0.05$).

Significant differences were found in the left thigh pressure mean, left thigh pressure peak, right thigh pressure ratio, and left thigh pressure ratio without cushion between the age groups ($p<0.05$) (Table 4). Significant differences were found in the right thigh pressure peak, right thigh pressure ratio, and left thigh pressure ratio of age groups sitting on the honeycomb cushion. Significant differences were found in the right thigh pressure mean, left thigh pressure mean, right thigh pressure peak, and left thigh pressure peak of age groups sitting on the air cushion ($p<0.05$). Significant difference was found in the right and left thigh pressure ratios between subjects on the memory foam cushion ($p<0.05$).

Table 3. Comparisons of hip pressure variables among groups (N=211, mmHg)

		Without cushion		Honeycomb cushion		Air cushion		Memory foam cushion	
		Mean ± SD	Tukey HSD	Mean ± SD	Tukey HSD	Mean ± SD	Tukey HSD	Mean ± SD	Tukey HSD
RH PM	A	71.0 ± 13.8	C>A,B,D C,A>B,D	50.7 ± 13.3	C,A>D,B C>A,D>B	59.1 ± 10.5	-	42.4 ± 8.7	C>A,D A>D,B
	B	65.7 ± 10.9		43.0 ± 9.2		50.5 ± 10.0		36.7 ± 7.2	
	C	78.3 ± 22.4		56.0 ± 15.3		61.6 ± 15.1		49.2 ± 13.4	
	D	64.8 ± 16.2		44.4 ± 19.1		50.0 ± 10.4		39.3 ± 11.7	
LH PM	A	83.0 ± 73.7	-	45.4 ± 11.9	C>A,B,D	47.9 ± 11.1	-	42.0 ± 9.2	C>A,D A>D,B
	B	65.2 ± 13.2		41.9 ± 17.5		48.9 ± 11.3		35.5 ± 8.2	
	C	84.9 ± 21.4		57.8 ± 18.4		62.6 ± 15.0		54.1 ± 15.7	
	D	63.7 ± 13.8		43.4 ± 13.6		50.9 ± 11.6		40.1 ± 11.5	
RH PP	A	276.0 ± 72.5	C,B,A>D	122.0 ± 67.2	C,A>B A,B>D	110.1 ± 49.5	-	143.7 ± 64.1	C,A>B,D C>A,B,D
	B	280.1 ± 79.6		100.2 ± 37.4		146.3 ± 40.5		126.8 ± 55.9	
	C	304.7 ± 88.7		139.3 ± 55.9		150.8 ± 49.5		170.3 ± 76.1	
	D	229.9 ± 84.6		94.2 ± 44.5		114.3 ± 35.7		115.9 ± 64.7	
LH PP	A	325.8 ± 80.2	C>A,B A>D	100.6 ± 43.4	C>A,B,D	97.5 ± 35.2	C,D,A>B C>D,A,B	144.3 ± 61.4	C>A,D,B
	B	269.0 ± 77.1		86.6 ± 35.8		104.3 ± 43.4		119.4 ± 69.0	
	C	325.8 ± 80.2		145.6 ± 60.3		142.8 ± 47.6		192.8 ± 83.8	
	D	234.2 ± 87.7		96.3 ± 39.3		118.0 ± 44.2		121.7 ± 56.0	
RH PR	A	36.4 ± 6.3	A>B,C,D A,B,C>D	35.5 ± 6.5	C,A,D>B A>D,B	28.0 ± 9.0	-	35.2 ± 5.9	-
	B	34.6 ± 4.9		30.7 ± 5.5		27.7 ± 3.8		33.3 ± 4.7	
	C	34.7 ± 4.7		33.1 ± 5.9		28.0 ± 3.4		35.1 ± 3.8	
	D	33.6 ± 3.9		30.0 ± 5.8		26.5 ± 3.3		34.1 ± 4.9	
LH PR	A	38.8 ± 8.5	A,C>B,D	30.1 ± 6.6	A>C,B,D	26.9 ± 11.5	-	34.7 ± 6.0	C>A,D,B
	B	34.1 ± 4.9		29.2 ± 6.6		26.7 ± 3.7		32.2 ± 5.6	
	C	37.7 ± 4.1		33.9 ± 6.7		28.5 ± 3.4		38.5 ± 4.4	
	D	33.2 ± 4.7		29.9 ± 6.7		26.9 ± 3.3		33.9 ± 5.3	

R/LHPM: right/left hip pressure mean, R/LHPP: right/left hip pressure peak, R/LHPR: right/left hip pressure mean ratio, A: male (60 years and older), B: female (60 years and older), C: males in their 20s, D: females in their 20s

The most preferred cushion was the honeycomb cushion with the highest preference rate of 42.4%, followed by the air cushion, 29.0%, the memory foam cushion, 28.1%, and without cushion, 0.5%. The second most preferred cushion was the memory foam cushion, followed by the honeycomb, air, and without cushion with rate of 41.2%, 35.1%, 20.9%, and 2.8%, respectively. The third most preferred cushion was the air cushion, followed by the memory foam, honeycomb, and without cushion with preference rates of 40.3%, 28.0%, 22.7%, and 9.0%, respectively. The fourth most preferred cushion was without a cushion, air, and memory foam cushions with preference rates of 87.6%, 10.0% and 2.4%, respectively (Table 5). The male subjects 60 years or older selected honeycomb (55.1%), memory foam (48.9%), air (46.9%), and without cushion (81.6%) as the most, second, third, and fourth most preferred cushions, respectively. The female subjects 60 years or older selected honeycomb (50.0%), memory foam (43.5%), air (48.4%), and without cushion (75.8%) as the most, second, third, and fourth most preferred cushion, respectively (Table 6). The male subjects in their 20s or older selected air (42.0%), memory foam (40.0%), honeycomb (36.0%), and without cushion as the most, second, third and fourth most preferred cushions, respectively. The female subjects in their 20s selected air (40.0%), honeycomb (38.0%), memory foam (38.0%), and without cushion as the most, second, third, and fourth most preferred cushion, respectively.

DISCUSSION

The present study analyzed changes in sitting pressure redistribution after adults 60 years or older and young adults in their 20s sat on pressure ulcer prevention cushions, such as honeycomb, air, and memory foam cushions along with no cushion.

The results of the present study are discussed below.

First, this study compared changes in the sitting pressures of the male and female subjects 60 years or older, and male and female subjects in their 20s while sitting on each cushion. A analysis of covariance (ANCOVA) was performed to eliminate the effects of common variables that are thought to affect sitting pressures, in addition to age and gender. In the ANCOVA, height, weight, and contact surface area were treated as covariates, and the mean total pressure, the mean hip pressure, the peak hip pressure, and hip pressure ratio were compared between groups divided by gender and age. The results show that

Table 4. Comparisons of thigh pressure variables among groups (N=211, mmHg)

		Without cushion (n=211)		Honeycomb cushion (n=211)		Air cushion (n=211)		Memory foam cushion (n=211)	
		Mean ± SD	Tukey HSD	Mean ± SD	Tukey HSD	Mean ± SD	Tukey HSD	Mean ± SD	Tukey HSD
RT PM	A	27.9 ± 29.5	-	27.3 ± 6.8	-	41.8 ± 5.8	C,D>A,B C>D,A,B	18.1 ± 4.1	-
	B	29.8 ± 9.1		28.2 ± 6.2		40.1 ± 5.1		19.1 ± 4.3	
	C	32.2 ± 13.5		27.6 ± 8.0		47.3 ± 12.3		18.1 ± 5.4	
	D	32.9 ± 13.9		29.8 ± 11.4		44.0 ± 12.7		19.7 ± 6.5	
LT PM	A	22.7 ± 7.1	D,B,C>A	26.9 ± 6.3	-	43.9 ± 5.9	C,D>A,B C>D,A,B	17.9 ± 4.0	-
	B	30.6 ± 11.3		27.5 ± 6.3		42.3 ± 6.1		18.6 ± 3.4	
	C	29.9 ± 8.0		27.8 ± 10.2		48.4 ± 10.6		18.1 ± 3.8	
	D	32.9 ± 14.2		28.9 ± 10.3		44.8 ± 12.0		19.2 ± 6.0	
RT PP	A	54.7 ± 29.9	-	59.0 ± 18.0	D>B,A,C D,B,A>C	99.0 ± 43.6	C>D,A,B C,D>A,B	48.9 ± 28.0	-
	B	72.3 ± 42.6		68.0 ± 21.6		100.7 ± 34.0		62.6 ± 51.7	
	C	77.7 ± 47.1		57.5 ± 23.1		114.1 ± 30.3		49.7 ± 41.6	
	D	81.6 ± 53.7		64.4 ± 27.4		117.0 ± 49.8		60.2 ± 59.0	
LT PP	A	48.0 ± 28.7	C,D,B>A C,D>B,A	56.9 ± 17.7	-	99.2 ± 28.3	C>D,A,B C,D>A,B	39.7 ± 20.9	-
	B	61.3 ± 20.7		57.0 ± 18.6		94.2 ± 23.2		43.3 ± 19.2	
	C	74.8 ± 50.8		59.4 ± 28.7		116.7 ± 41.2		46.6 ± 29.6	
	D	72.7 ± 39.3		65.9 ± 37.0		112.9 ± 58.0		49.1 ± 29.4	
RT PR	A	13.2 ± 7.2	D>B,C,A D,B,C>A	18.3 ± 4.6	D,B,A>C B>A,C	22.0 ± 4.8	-	15.2 ± 3.8	B,D>A D,A>C
	B	15.5 ± 3.9		20.2 ± 4.0		22.2 ± 2.8		17.5 ± 3.8	
	C	14.2 ± 4.5		16.4 ± 3.6		21.4 ± 3.0		13.1 ± 3.1	
	D	16.6 ± 4.0		20.3 ± 4.5		23.1 ± 3.2		16.6 ± 3.9	
LT PR	A	11.6 ± 3.4	D,B>C,A	18.1 ± 4.3	D,B,A>C D,B>A,C	23.1 ± 5.0	-	14.9 ± 3.2	B,D>A D,A>C
	B	15.8 ± 4.7		19.8 ± 4.6		23.4 ± 3.0		17.0 ± 3.2	
	C	13.4 ± 2.5		16.5 ± 4.1		22.1 ± 2.7		13.3 ± 2.9	
	D	16.6 ± 3.7		19.8 ± 4.1		23.5 ± 2.9		16.3 ± 3.2	

R/LTPM: right/left thigh pressure mean, R/LTPP: right/left thigh pressure peak, R/LTPR: right/left thigh pressure mean ratio, A: male (60 years and older), B: female (60 years and older), C: males in their 20s, D: females in their 20s

Table 5. Cushion preference of entire subjects (N=211, Score)

	Without cushion	Honeycomb cushion	Air cushion	Memory foam cushion
1st	0.5	42.4	29.0	28.1
2nd	2.8	35.1	20.9	41.2
3rd	9.0	22.7	40.3	28.0
4th	87.6	0.0	10.0	2.4

Table 6. Cushion preference based on age and gender (Score)

	Males in their 20s (n=49)				Females in their 20s (n=62)				Males 60 years and older (n=50)				Females 60 years and older (n=50)			
	F	H	A	M	F	H	A	M	F	H	A	M	F	H	A	M
1st	2.0	30.0	42.0	26.0	0.0	34.0	40.0	26.0	0.0	55.1	22.4	22.4	0.0	50.0	14.5	35.5
2nd	0.0	34.0	26.0	40.0	38.0	26.0	34.0	0.0	6.1	30.6	14.3	48.9	1.7	37.1	17.7	43.5
3rd	0.0	36.0	30.0	2.0	28.0	34.0	38.0	0.0	12.2	14.3	46.9	26.5	21.0	14.5	48.4	16.1
4th	98.0	0.0	2.0	34.0	0.0	0.0	2.0	98.0	81.6	0.0	16.3	2.0	75.8	0.0	19.4	4.8

F: firm surface, H: honeycomb cushion, A: air cushion, M: memory foam cushion

gender and age had significant effects on the mean total pressure, mean hip pressure, and peak hip pressure. Weight affected on the mean total pressure and right hip pressure ratio, whereas height had no effect on any variables. The total contact surface area had significant effects on the mean right hip pressure, peak right hip pressure, and right hip pressure ratio. Stinson investigated the correlations between average pressure, maximum pressure, gender, and body mass index (BMI) in 63 able-bodied subjects. Mean pressure, and maximum pressure were found to be independent of gender, and no significant correlation was found between height or weight and mean pressure, but a significant correlation was found between BMI and mean pressure ($r=0.381$, $p<0.01$)[10]. In a study by Cho, weight and BMI were found to affect the mean pressure, total contact area, and high-pressure area ratio ($p<0.05$)[11]. According to reports, height is less correlated with pressure; however, weight and BMI are variables that significantly affect sitting pressure, and age and gender are also thought to significantly affect sitting pressure. In future studies, it will be necessary to classify weight as a variable and perform analysis by using BMI.

The group of males in their 20s had the highest hip pressure on all cushions excluding air cushion, followed by females 60 years or older, males 60 years or older, and females in their 20s ($p<0.05$). The males in their 20s showed similar results to those in males 60 years or older, but a significant difference was found between the females in their 20s and those 60 years or older. The males 60 years or older showed a similar tendency to females 60 years or older and those in their 20s. The peak right hip pressure was the highest for the males in their 20s, followed by females 60 years or older, males 60 years or older, and females in their 20s, and was significantly higher in the other groups than that of females in their 20s ($p<0.05$). The left hip pressure was the highest for the males in their 20s, followed by men 60 years or older, women 60 years or older, and women in their 20s. Significant differences were found between males in their 20s and all of the other groups, and a significant difference was found between males 60 years or older and females in their 20s, but no significant difference was found between females 60 years or older and females in their 20s. The mean pressure ratio was the highest for the males men aged 60 years or older, followed by males in their 20s, females 60 years or older, and females in their 20s, and was found between males in their 20s and all of the other groups ($p<0.05$). The mean hip pressure, peak hip pressure, and mean hip pressure ratio were higher for males, whereas the mean thigh pressure and mean thigh pressure ratio were higher for females. This is possibly because males generally weigh higher than females and thus, pressure applied by body weight is also high. This may be explained by differences in body composition pattern, such as age, body fat, and muscle mass.

The cushion preference was compared between males and females in their 20s, and the males and females 60 years or older. The most, second, third, and fourth preferred cushions were honeycomb, memory foam, air, and without cushion, respectively. When the correlations between cushion preference and subjective sensibility evaluation regarding pressure distribution and seats were investigated, statistically strong correlations were found[12]. In this regard, the air cushion that had higher mean pressure and peak thigh pressure compared with the other cushions was selected as the third most preferred cushion. The reason why the honeycomb cushion was selected as the most preferred cushion despite the fact that the memory foam cushion had the lowest mean pressure seems to be because the honeycomb cushion had a relatively low mean pressure and exhibited to the lowest peak pressure. By age group, the men and women in their 20s selected the honeycomb cushion as the most preferred cushion, whereas the adults 60 years or older selected the air cushion as the most preferred cushion. In addition, the men and women in their 20s had a higher preference for without cushion than older adults, and indicated a clearer preference among the cushions than the older adults. Although similarities were found in the cushion pressure distribution tendency between the young and older adults. The older adults were interpreted as preferring cushions with low peak pressures in a localized area, compared to young adults. Because interpreting cushion preference by using only pressure has limitations, further studies regarding reasons for cushion preference are necessary in the future.

ACKNOWLEDGEMENT

This work was supported by the Soonchunhyang University Research Fund.

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