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Original Article

Comparing the interface pressure redistribution after applying three different types of cushions: differences according to cushion type

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Abstract. [Purpose] The purpose of this study was to compare the interface pressure redistribution when sitting after applying three different types of cushions and on a firm surface in individuals in their 20s and those older than 60 years old. [Subjects and Methods] Healthy 100 elderly (60 years and older) subjects and 111 college students participated in this study. Interface pressure redistribution while sitting on a firm surface or honeycomb, air, and memory foam cushions, examined in that order. [Results] For all groups, significant differences were found in the total pressure mean among sitting states. When the hip and thigh interface pressure among sitting states were compared within each group, significant differences were found in the mean right hip pressure, mean left hip pressure, peak right hip pressure, peak left hip pressure, right hip pressure ratio, and left hip pressure ratio. [Conclusion] Our data indicated that the type of cushion should be considered and fit for individuals when recommending appropriate interface pressure redistribution cushions.

Key words: Interface pressure, Pressure mapping, Pressure relief cushion

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INTRODUCTION

Pressure relief cushions range from a simple pillow-like to an individualized conforming cushion with gel or raised air-filled pockets. It is unclear which type of cushion is appropriate for the elderly to relieve interface pressure. A previous study by Hong et al. compared and analyzed the form of air cushions, heights of air cells, and thickness of air cells in 7, 7, 9, 10, and 7 individuals with left hemiplegia, right hemiplegia, paraplegia, quadriplegia, and without disability, respectively[1, 2)]. An et al. compared the sitting pressure distribution based on the type of cushion for pressure ulcer prevention in 26 healthy adults. An and Gong also analyzed the effects of the type of cushion, air, marble, foam, and gel cushion, and backrest angle on the sitting interface pressure in 14 healthy adults[3, 4)]. Another study analyzed the sitting interface pressure while sitting on low-profile air, high-profile air, dual-compartment air, and gel and firm foam in a population with spinal cord injury[5)].

Interface pressure studies when applying pressure relief cushions have investigated on healthy young adults less than 60 and people with disability, spinal cord injury and stroke. Moreover, analyzed interface pressure variables and interface areas were limited and broad to use as reference data to recommend an appropriate cushion. So, recommending appropriate pressure relief cushion type for the elderly have been restricted.

Therefore, this study explored the changes in the interface pressure redistribution using various interface pressure variables of four interface areas when sitting on cushions, air, honeycomb, and foam in 60 years healthy adults of age or older and in their 20s.

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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

SUBJECTS AND METHODS

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

The ConFORMat system was used for interface pressure mapping, and V.7.2 ×research software was used for data acquisition (both from Tecksan Inc., MA, USA). The 1024 CONFORTMat sensors are thin and flexible. The horizontal axis comprised of sensors labeled 1 to 32, with the vertical axis labeled A to FF (32 × 32). The sitting interface pressure was measured in mmHg, and the number of frames was set to 60 per minute. The ConFORMAT was placed on every cushion during data acquisition. One occupational therapist and two university students collected the pressure data. After the participants' height and weight were measured, the participants adjusted their posture in a sitting position by using a footstool. While sitting, participants were instructed to keep their chins tucked, spines straight, pelvis neutrally positioned, and 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, footing 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 to not exceed a 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 subject's general information was acquired, the sitting interface 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 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 and sitting on firm surface were referred to as sitting state 1, 2, 3, and 4, and thus the subjects were informed only of the change in cushion and were provided no information regarding the specific cushion type. After all measurements were obtained, the cushion preference was measured by instructing the subjects to select the most preferred sitting state.

After all measurements were obtained, the interface 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 interface pressure on the cushion. A set of 60 frames was used for data analysis, excluding data for 10 s from both the beginning and end of the obtained data to protect the measurements used for interface pressure analysis from contamination by the surrounding environment[6].

After the sitting interface pressures were measured, the mean and peak pressures in the four quadrants (left hip/left thigh/right hip/right thigh) were calculated. The peak pressure was the mean of the maximum pressures measured with four sensors in each quadrant during sitting. The mean pressure ratio was calculated as A ratio=A mean/(A mean + B mean + C mean + D mean) ×100. A ratio indicates the mean pressure ratio, and A mean can be the mean pressure in 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 in the remaining areas. The pressure mean and mean pressure ratio was calculated by the same method of peak pressure and peak pressure ration with every sensors in each quadrant.

The Statistical Package for the Social Sciences 22.0 was used for statistical analyses. One-way analysis of variance was used to determine differences among sitting states, and Tukey's post-hoc test was performed. The significant level was 0.05.

Table 2. Comparison of the total pressure means among cushions (mmHg)

	Elderly men (N=50)		Elderly women (N=50)		Young men (N=49)		Young women (N=62)	
	Mean ± SD	Tukey HSD	Mean ± SD	Tukey HSD	Mean ± SD	TukeyHSD	Mean ± SD	Tukey HSD
F	47.5 ± 7.0		47.8 ± 6.6		56.3 ± 12.9		48.6 ± 12.0	
H	37.6 ± 4.5	M>H> F,A	35.2 ± 5.9	M>H> A,F	42.3 ± 9.2	M>H> A,F	36.6 ± 10.7	M>H> A,F
A	48.2 ± 14.6		45.5 ± 5.4		55.0 ± 11.0		47.4 ± 10.0	
M	30.1 ± 3.0		27.5 ± 3.1		34.9 ± 8.1		29.6 ± 7.2	

TPM: total pressure mean; A: air cushion; H: honeycomb cushion; M: memory foam cushion; F: firm surface

Table 3. Comparison of hip interface pressure variables among cushions (mmHg)

		Elderly men (N=50)		Elderly women (N=50)		Young men (N=49)		Young women (N=62)	
		Mean ± SD	Tukey HSD	Mean ± SD	Tukey HSD	Mean ± SD	Tukey HSD	Mean ± SD	Tukey HSD
RH PM	F	71.0 ± 13.8	F,A>H A>M	65.7 ± 10.9	F>A,H A>M	78.3 ± 22.4	F,A>H A>M	64.8 ± 16.2	F>A>H>M
	H	50.7 ± 13.3		43.0 ± 9.2		56.0 ± 15.3		44.4 ± 19.1	
	A	59.1 ± 10.5		50.5 ± 10.0		61.6 ± 15.1		50.0 ± 10.4	
	M	42.4 ± 8.7		36.7 ± 7.2		49.2 ± 13.4		39.3 ± 11.7	
LH PM	F	83.0 ± 73.7	F>A,H,M	65.2 ± 13.2	F>A>H,M	84.9 ± 21.4	F>A,H,M	63.7 ± 13.8	F>A>H,M
	H	45.4 ± 11.9		41.9 ± 17.5		57.8 ± 18.4		43.4 ± 13.6	
	A	47.9 ± 11.1		48.9 ± 11.3		62.6 ± 15.0		50.9 ± 11.6	
	M	42.0 ± 9.2		35.5 ± 8.2		54.1 ± 15.7		40.1 ± 11.5	
RH PP	F	276.0 ± 72.5	F>M,H M>A	280.1 ± 79.6	F>M,A,H	304.7 ± 88.7	F>M,H M>A	229.9 ± 84.6	F>A,M,H
	H	122.0 ± 67.2		100.2 ± 37.4		139.3 ± 55.9		94.2 ± 44.5	
	A	110.1 ± 49.5		146.3 ± 40.5		150.8 ± 49.5		114.3 ± 35.7	
	M	143.7 ± 64.1		126.8 ± 55.9		170.3 ± 76.1		115.9 ± 64.7	
LH PP	F	325.8 ± 80.2	F>M>H,A	269.0 ± 77.1	F>M,A,H	325.8 ± 80.2	F>M>H,A	234.2 ± 87.7	F>M,A M>H
	H	100.6 ± 43.4		86.6 ± 35.8		145.6 ± 60.3		96.3 ± 39.3	
	A	97.5 ± 35.2		104.3 ± 43.4		142.8 ± 47.6		118.0 ± 44.2	
	M	144.3 ± 61.4		119.4 ± 69.0		192.8 ± 83.8		121.7 ± 56.0	
RH PR	F	36.4 ± 6.3	F,M,H>A	34.6 ± 4.9	F,M>H>A	34.7 ± 4.7	F,M,H>A	33.6 ± 3.9	F,M>H>A
	H	35.5 ± 6.5		30.7 ± 5.5		33.1 ± 5.9		30.0 ± 5.8	
	A	28.0 ± 9.0		27.7 ± 3.8		28.0 ± 3.4		26.5 ± 3.3	
	M	35.2 ± 5.9		33.3 ± 4.7		35.1 ± 3.8		34.1 ± 4.9	
LH PR	F	38.8 ± 8.5	F,M>H,A	34.1 ± 4.9	M,F>H>A	37.7 ± 4.1	F,M>H,A	33.2 ± 4.7	F,M>H,A
	H	30.1 ± 6.6		29.2 ± 6.6		33.9 ± 6.7		29.9 ± 6.7	
	A	26.9 ± 11.5		26.7 ± 3.7		28.5 ± 3.4		26.9 ± 3.3	
	M	34.7 ± 6.0		32.2 ± 5.6		38.5 ± 4.4		33.9 ± 5.3	

R/LHPM: right/left hip pressure mean, R/LHPP: right/left hip pressure peak, RR/LHPR: right/left hip pressure mean ratio, A: air cushion, H: honeycomb cushion, M: memory foam cushion, F: firm surface

RESULTS

For all groups, statistically significant differences were found in the total mean pressure among sitting states ($p<0.05$) (Table 2). The total mean pressure was the lowest and the second lowest on memory foam and honeycomb cushions, respectively. No significant difference was found in the interface pressure while sitting without a cushion and on an air cushion.

When the hip and thigh interface pressures were compared among sitting state within each group, 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 ($p<0.05$) (Table 3). And the interface pressure was the highest on a firm surface and the ratio was the highest on the air cushion. The all-thigh interface pressure variables were the lowest on a memory foam cushion and the highest on an air cushion (Table 4).

Table 4. Comparison of thigh interface pressure variables among cushions (mmHg)

		Elderly men (N=50)		Elderly women (N=50)		Young men (N=49)		Young women (N=62)	
		Mean ± SD	Tukey HSD	Mean ± SD	Tukey HSD	Mean ± SD	Tukey HSD	Mean ± SD	Tukey HSD
RT PM	F	27.9 ± 29.5	A>F,H>M	29.8 ± 9.1	A>F,H>M F>M	32.2 ± 13.5	A>H>F>M	32.9 ± 13.9	A>F,H>M
	H	27.3 ± 6.8		28.2 ± 6.2		27.6 ± 8.0		29.8 ± 11.4	
	A	41.8 ± 5.8		40.1 ± 5.1		47.3 ± 12.3		44.0 ± 12.7	
	M	18.1 ± 4.1		19.1 ± 4.3		18.1 ± 5.4		19.7 ± 6.5	
LT PM	F	22.7 ± 7.1	A>F,H>M	30.6 ± 11.3	A>F,H>M	29.9 ± 8.0	A>H>F>M	32.9 ± 14.2	A>F,H>M
	H	26.9 ± 6.3		27.5 ± 6.3		27.8 ± 10.2		28.9 ± 10.3	
	A	43.9 ± 5.9		42.3 ± 6.1		48.4 ± 10.6		44.8 ± 12.0	
	M	17.9 ± 4.0		18.6 ± 3.4		18.1 ± 3.8		19.2 ± 6.0	
RT PP	F	54.7 ± 29.9	A>F>H,M	72.3 ± 42.6	A>F,H,M	77.7 ± 47.1	A>H,F,M	81.6 ± 53.7	A>F,H,M
	H	59.0 ± 18.0		68.0 ± 21.6		57.5 ± 23.1		64.4 ± 27.4	
	A	99.0 ± 43.6		100.7 ± 34.0		114.1 ± 30.3		117.0 ± 49.8	
	M	48.9 ± 28.0		62.6 ± 51.7		49.7 ± 41.6		60.2 ± 59.0	
LT PP	F	48.0 ± 28.7	A>F,H F>M	61.3 ± 20.7	A>F,H F>M	74.8 ± 50.8	A>H,F H>M	72.7 ± 39.3	A>F,H>M
	H	56.9 ± 17.7		57.0 ± 18.6		59.4 ± 28.7		65.9 ± 37.0	
	A	99.2 ± 28.3		94.2 ± 23.2		116.7 ± 41.2		112.9 ± 58.0	
	M	39.7 ± 20.9		43.3 ± 19.2		46.6 ± 29.6		49.1 ± 29.4	
RT PR	F	13.2 ± 7.2	A>H>F,M	15.5 ± 3.9	A>H>F,M	14.2 ± 4.5	A>H>M,F	16.6 ± 4.0	A>H>M>F
	H	18.3 ± 4.6		20.2 ± 4.0		16.4 ± 3.6		20.3 ± 4.5	
	A	22.0 ± 4.8		22.2 ± 2.8		21.4 ± 3.0		23.1 ± 3.2	
	M	15.2 ± 3.8		17.5 ± 3.8		13.1 ± 3.1		16.6 ± 3.9	
LT PR	F	11.6 ± 3.4	A>H>F,M	15.8 ± 4.7	A>H>F,M	13.4 ± 2.5	A>H>M>F	16.6 ± 3.7	A>H>M,F
	H	18.1 ± 4.3		19.8 ± 4.6		16.5 ± 4.1		19.8 ± 4.1	
	A	23.1 ± 5.0		23.4 ± 3.0		22.1 ± 2.7		23.5 ± 2.9	
	M	14.9 ± 3.2		17.0 ± 3.2		13.3 ± 2.9		16.3 ± 3.2	

R/LTPM: Rt./Lt. thigh pressure mean; R/LTPP: Rt./Lt. thigh pressure peak; R/LTPR: Rt./Lt. thigh pressure mean ratio; A: air cushion; H: honeycomb cushion; M: memory foam cushion; F: firm surface

DISCUSSION

1) When the effects of sitting states were compared within each group of men in their 20s, women in their 20s, men 60 years or older, and women 60 years or older, the mean hip pressure was the highest when sitting on a firm surface, followed by air, honeycomb, and memory foam cushions, and the peak hip pressure was the highest without a cushion, followed by memory foam, air, and honeycomb cushions. The mean thigh pressure tended to be the highest when sitting on an air cushion, followed by without a cushion, honeycomb, and memory foam cushions. The peak thigh pressure was the highest for air cushions, followed by without, honeycomb, and memory foam cushions. These results were inconsistent with the results of previous studies that had indicated that the existing air cushion was more effective in reducing hip pressure compared with other cushions. In a study by An and Gong analyzing the mean sitting pressure distribution based on mean pressure index in the contact area, the air-filled cushion showed a lower result compared with other cushions ($p<0.05$)[4]. However, in the present study, the mean pressure was found to be the second highest when sitting on an air cushion after sitting without a cushion.

A study by An et al. indicated that the peak pressure index was statistically lower when sitting on an air cushion compared with other cushion types[3]. Considering studies in foreign countries, a study by Bar showed that when applying foam, gel, and air cushions to 25 patients with spinal cord injury, the mean pressures were found to be 87.6 mmHg, 68.6 mmHg, and 54.6 mmHg, respectively, indicating that the mean pressure was lower sitting on an air cushion[7]. In a previous study, comparing the effects of six sitting postures for foam and air cushions in six patients with spinal cord injury and eight able-bodied subjects, ischial pressure was found to be the lowest when sitting on an air cushion[8]. Tanimoto found in a study of 19 patients with spinal cord injury that an air cushion was the most effective for hip pressure redistribution among the five kinds of toilet seat cushions[9]. Eksteen confirmed that the lowest pressure was observed when using an air cushion among three toilet seat cushions in 10 patients with spinal cord injury[10]. In a study by Sharon et al., 17 wheelchair users were instructed to perform pressure relief maneuvers while sitting on each of a wheelchair-air cushion, fluid pocket-type cushion enclosed with foam base (J2), and multi-layered foam cushion to determine the ischial pressure generated at the ischial tuberosity through within-subject measurements[11]. As a result, the ischial pressure was found to be the lowest when using the air cushion during upright sitting and small leans except for full front/side leans and intermediate side leans. In contrast, some studies did not confirm a statistically superior performance of air cushions, although the pressure on the air cushion was lower when compared with other cushions. In a study by Gilsdorf, a similar ischial pressure distribution was observed on Roho and Jay cushions in 10 normal subjects[12]. In a study by DiGiovine et al. examining the mean pressure in the area, including the ischial tuberosity and sacrum, for seven patients with spinal cord injury, significant differences were found between air and foam cushions and significant differences were also found between foam and honeycomb cushions. However, a statistical superiority was not confirmed between air and honeycomb cushions[13]. The results of this study showed that the mean sitting pressure of the air cushion was higher, unlike the results of previous studies. This may be because the cushion stiffness may have been higher from a failure to use standardized air pressure-controlled methods and monitor air pressure levels to ensure continuous air supply against any ongoing air leak. Although the mean pressure was high in the present study, the hip pressure peak was the second lowest on the air cushion, and significant differences were found in the mean hip pressure ratio between air and other cushions. Differences between air and other cushions appeared prominently in the mean pressure ratio. It is believed that when sitting on the air cushion, the mean hip pressure ratio was low and the mean thigh pressure ratio was high because the air cushion has a greater effect on redistributing the interface pressure toward the thighs compared with other cushions.

For the memory foam cushion, the peak hip pressure was significantly higher in all groups except for the group of women 60 years or older. Shabshin et al. evaluated pressures on two standard commercial viscoelastic cushions, two foam cushions, and a rigid support in a study of 10 participants[14]. The results of that study showed that the peak pressure on the memory foam cushion was higher than that on a foam cushion. The memory foam cushion has a good viscoelasticity to offer appropriate contact surface during sitting and has an excellent envelopment compared with using no cushion; thus, the mean hip pressure and the mean total pressure were found to be low. However, the peak hip pressure was found to be the second highest on memory foam cushion behind sitting without a cushion. Judging from these, the peak hip pressure is thought to be high because the soft polyurethane foam of the memory foam cushion is very soft, and thus, a bottomed-out condition can occur during sitting, generating high pressure.

On the honeycomb cushion, the peak pressure in the hips was found to be the lowest. The honeycomb cushion is light, has a good support surface, absorbs shock well, cools the skin, easy to wash, and has no leakage risk, but related records are scarce because it is relatively new type of cushion compared with the other cushions.

Further studies involving new cushion materials and other physical elements, such as temperature, moisture, friction, and shearing force, should be conducted. Also, standardized air pressure level of air cushion must be investigated.

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REFERENCES

1) Hong JH, Kim GS, Chu JU, et al.: Fuzzy logic controlled seat cushion orthosis to prevent decubitus ulcer. J Korean Soc Precis Eng, 2003, 20: 7–25.
2) Park YO, Joo YH, Lee NJ, et al.: Factors influencing health service utilization of older adults in nursing homes. Korean Gerontological Nurs Soc, 2010, 12: 10–20.
3) An NY, Joo JD, Song GH, et al.: Comparison of cushion for prevention of pressure ulcer on seated pressure. J Assist Technol, 2010, 4: 45–55.
4) An NY, Gong JY: Comparison of cushions for prevention of pressure ulcers and backrest angle on seated pressure. J Korean Soc Occup Ther, 2011, 19: 105–115.
5) 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]
6) Mergl C, Klendauer M, Mangen C, et al.: Predicting long term riding comfort in cars by contact forces between human and seat. SAE. Technical Paper, no. 2005-01-2690, 2005.
7) Thomas DR: Prevention and treatment of pressure ulcers. J Am Med Dir Assoc, 2006, 7: 46–59. [Medline] [CrossRef]
8) Koo TK, Mak AF, Lee YL: Posture effect on seating interface biomechanics: comparison between two seating cushions. Arch Phys Med Rehabil, 1996, 77: 40–47. [Medline] [CrossRef]
9) Tanimoto Y, Takechi H, Nagahata H, et al.: The study of pressure distribution in sitting position on cushions for patient with SCI (spinal cord injury). IEEE Trans Instrum Meas, 1998, 27: 1239239t.
10) Eksteen C, Cilliers P, Swanepoel A, et al.: A comparative study of two pressure relieving techniques on three different wheelchair cushions. SA J Physiother, 2006, 62.
11) Sonenblum SE, Vonk TE, Janssen TW, et al.: Effects of wheelchair cushions and pressure relief maneuvers on ischial interface pressure and blood flow in people with spinal cord injury. Arch Phys Med Rehabil, 2014, 95: 1350–1357. [Medline] [CrossRef]
12) Gilsdorf P, Patterson R, Fisher S, et al.: Sitting forces and wheelchair mechanics. J Rehabil Res Dev, 1990, 27: 239–246. [Medline] [CrossRef]
13) DiGiovine C, Nahikian-Nelms M, White S, et al.: The dispersion index as a metric for measuring pressure distribution on seat surfaces: a pilot study. RESNA Annual Conference, 2015.
14) Shabshin N, Zoizner G, Herman A, et al.: Use of weight-bearing MRI for evaluating wheelchair cushions based on internal soft-tissue deformations under ischial tuberosities. J Rehabil Res Dev, 2010, 47: 31–42. [Medline] [CrossRef]