Rehabilitation Practice and Science

Volume 38
Issue 4 *Taiwan Journal of Physical Medicine and Rehabilitation (TJPMR)*

Article 1

12-31-2010

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Recommended Citation

Kao, Mu-Jung; Tsuang, Yang-Hwei; Kuo, Chi-Jou; Chou, Jen-Ling; Wei, Hung-Wen; and Tsai, Mei-Wun (2010) "The Effect of a New Gelatinous Elastomers Cushion on Reducing Pressure and Temperature," *Rehabilitation Practice and Science*: Vol. 38: Iss. 4, Article 1.
DOI: https://doi.org/10.6315/2010.38(4)02
Available at: https://rps.researchcommons.org/journal/vol38/iss4/1

The Effect of a New Gelatinous Elastomers Cushion on Reducing Pressure and Temperature

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Original Article

The Effect of a New Gelatinous Elastomers Cushion on Reducing Pressure and Temperature

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Objective: The aim of this study was to analyze the effectiveness of a new air cell cushion (Elaston cushion) made of gelatinous elastomers, a newly developed material with a novel structure on reducing pressure and temperature.
Methods: We compared the pressure and thermal responses of the Elastone cushion to three other available cushions (foam, gel-filled and air-filled villous) and four regular wooden or spongy chair seats. The skin temperature at the buttocks was also continuously measured for eight-hours sitting.
Results: The Elastone cushion reduced the peak pressure (39.7 mmHg) compared with foam (60.0 mmHg), gel-filled (60.3 mmHg) and air-filled cushions (69.3 mmHg), as well as with the wooden and spongy chair seats (84.7 to 200 mmHg). The peak temperature with the Elastone cushion was 29℃. Higher temperatures were found with the gel-filled (33.8℃), air-filled (35℃) and foam (35.9℃) cushions, as well as with the wooden and spongy chair seats (34.5 to 35.9℃).
Conclusion: Our findings clearly showed that the Elastone cushion was more advantageous in relieving pressure and minimizing temperature. (Tw J Phys Med Rehabil 2010; 38(4): 215 - 222)

Key Words: cushion, pressure, temperature, gelatinous elastomers, air cell, thermometer, FSA pressure monitor system

INTRODUCTION

Prevention of sitting-acquired pressure sores is an important objective in the rehabilitation of wheelchair-bound individuals. Seat cushions are commonly suggested to relieve pressure and reduce the risk of pressure sores in this population. No single cushion on the market is optimal for all users.[1-4] Despite the diversity of cushions already for clinical use, new materials and structures have been developing not only to relieve pressure but also to decrease thermal accumulation.

The material and structure of seat cushions affects the effectiveness to reduced pressure and temperature of the contact area. Some studies have demonstrated that air and gel-filled cushions are more advantageous in relieving pressure sores compared with foam-filled cushions.[5-7] Other studies have reported that contoured seat cushions

Submitted date: 25 February 2010 Revised date: 8 June 2010 Accepted date: 15 June 2010
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are better at stabilizing sitting posture than flat-surfaced seats, especially for disabled persons with poor trunk control and abnormal sitting posture.[3,8,9] Based on the evidence that higher interface pressure is associated with a higher incidence of pressure sores among the disabled,[6,10,11] the magnitude and distribution of pressure have been used as the primary indicators in the comparative evaluation of cushions.[5,9,12-16] However, other factors such as temperature, moisture, nutrition, and seating position have been also identified as the contributing factors of pressure sore formation.[17,18] Increase of skin temperature at the body areas in contact with the seat and the stagnant blood in the calf and thigh caused various discomforts.[19] In particular, wheelchair users often sit for a long period of time in their daily activities. Therefore, other criteria for the assessment of cushions, such as the thermal property and seat comfort, may also be needed for solving the problems resulting from prolonged sitting.

There are limited data on the thermal responses of the various types of cushion. Shvartz et al addressed the effect of a massage-type seat cushion on skin temperature [19] and Ferrarin et al recently reported an analysis of thermal properties to differentiate between different wheelchair cushions.[20] It would be interesting to know the effect of different cushions on both pressure and thermal responses simultaneously; the results of such a study ought to provide more integrated information for selecting cushions. Most seat cushions available in the market do not reduce pressure adequately and accumulate excessive heat in the contact areas; therefore, we tried to develop a new material and novel structure for a seat cushion. The first aim of this study is to identify the effectiveness of the new air cell cushion (Elaston cushion) made of gelatinous elastomers on reducing pressure and temperature. The second aim is to compare the pressure and thermal responses at the contact areas among different cushions and seats.

METHODS

Design of the structured air cell Elastone cushion

The Elastone cushion (All-Scope, Magic Seat, SP-SCV460) was developed by our team for the patients who require to sit for a long period of time. The cushion incorporates the properties of minimizing temperature, pressure relief and posture support. It is made with gelatinous elastomers, (polystyrene-hydrogenated poly (isoprene+butadiene)-polystyrene), and consists of multiple structured air cells and communicating pores between the cells. The gelatinous elastomers have good elasticity and are light in weight. Heat is easily ventilated through communicating pores. The shape is contoured to support a larger buttock area (Figure 1, 2).

Selected seats and cushions for the comparative evaluation

We compared the peak pressure and temperature of the Elastone cushion with three other cushions, foam, gel-filled (All-Scope, Soft Cushion, SP-CV460, 16×16 inch^2) and air-filled villous (ROHO). For reference, we compared the Elastone cushion using four commercially available chairs, a wooden chair, a textile-face spongy sofa, a plastic-face spongy sofa and a leather-face spongy sofa.

Subject

A 26-year-old female (body height: 163 cm; body weight: 67 kg; fat composition: 46% and axillary temperature: 36.6°C) volunteered to sit for the measurements to be taken. She sat on each of the cushions and chairs in the same procedures for eight hours.

Pressure measurement

Pressure was measured by an FSA pressure monitor system (VERG Inc. Canada) (Figure 3). A cellular force plate was placed between the buttocks and either the cushions or the chair seats. The real time pressure distributions of the buttocks were automatically imaged on the monitor system. Average peak pressure was determined from three measurements of peak pressure.

Temperature measurement

Under a controlled environment of 22°C room temperature, the subject was instructed to sit in a comfortable position on each of the cushions for eight hours. A body surface thermometer (HP Omni Care CMS 24) continuously measured the temperature at the sensor plate at the midpoint of the buttocks (Figure 4).

Data analysis

A descriptive report of the mean and standard deviation was applied in this single subject study. The thermal responses on the various cushions were compared by their time trend curve and the maximal temperature, each achieved from the continuous eight-hour prolonged period.

RESULTS

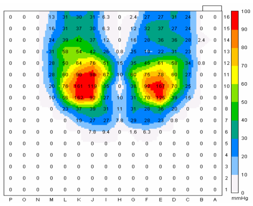
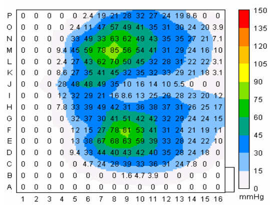
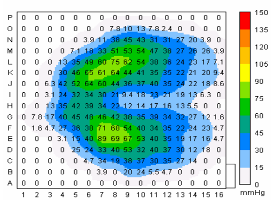
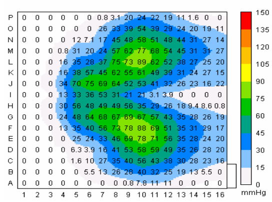
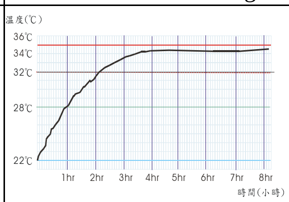
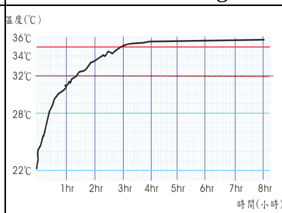
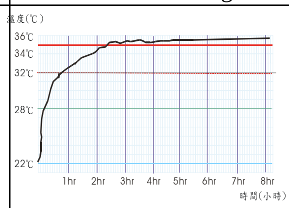
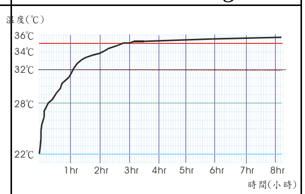
Comparison of the pressure and thermal properties among the various cushions and seats are shown in Table 1 and 2. All of the selected cushions were effective at reducing the peak pressure. Compared with the three other cushions, the Elastone cushion had the lowest peak pressure (39.7±1.5 mmHg).

During the eight-hour period, temperature gradually increased and generally reached its maximal plateau within three hours. The Elastone cushion had the lowest maximal temperature (less than 29°C). There was a similar initial temperature (27°C) measured at the first hour of gel-filled and Elastone cushions, but the temperature of gel-filled cushion increased to 33.8℃ in the following two hours. Both ROHO and foam cushions increased their temperature to approximately 35℃ rapidly in the first hour. Their peak temperatures were 35°C and 35.9°C, respectively, which were similar to the peak temperature of the regular chair seats.

DISCUSSION

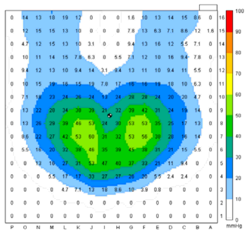
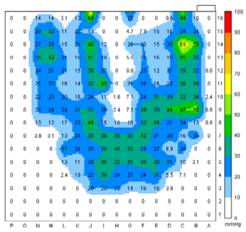
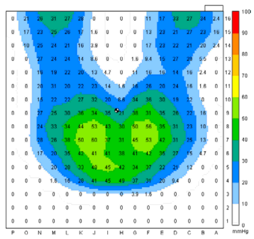
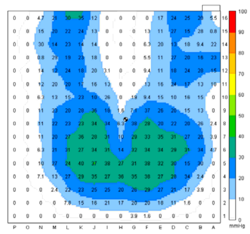
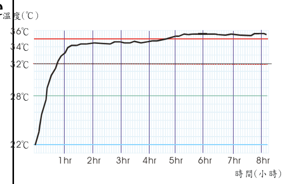
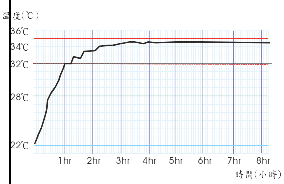
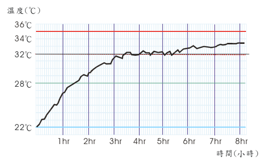
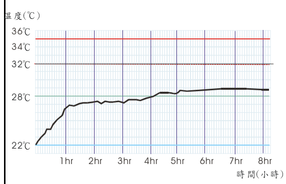
The main goal of this study was to evaluate the advantages of pressure relief and heat dissipation of the Elastone cushion in order to meet the need of people who must sit for a long period of time. Our results showed that the structured air cell cushion distributed pressure better and maintained a more comfortable temperature after a prolonged period than the other cushions.

Table 1. Comparison of pressure and thermal properties among the various regular chairs

Types of Seats	House Chair	Office Chair	Plastic-face Sofa	Leather-face Sofa
Material	Wooden	Textile-face and spongy	Plastic-face and spongy	Leather-face and spongy
Sample				
Pressure property				
Peak pressure	More than 200 mmHg	84.7±0.6 mmHg	89.0±1.0 mmHg	89.3±0.6 mmHg
Thermal response				
Peak temperature	34.5℃	35.9℃	35.9℃	35.0℃

*test subject: A 26-year-old female (height, 163 cm; weight, 67 kg; fat composition, 46%; temperature, 36.6°C), volunteered to sit for a prolonged period while measurements were taken. She sat on all of the cushions and chairs in the same procedures.

Table 2. Comparison of pressure and thermal properties among the various cushions

Types of Cushions	Foam	ROHO	Gel	Elastone
Material	Spongy	Air-filled villous rubber	Gel-filled	Structured air cells
Sample				
Pressure property				
Peak pressure	60.0±2.0 mmHg	69.3±0.6 mmHg	60.3±1.5 mmHg	39.7±1.5 mmHg
Thermal response				
Peak temperature	35.9℃	35.0℃	33.8℃	29.0℃

*test subject: A 26-year-old female (height, 163 cm; weight, 67 kg; fat composition, 46%; temperature, 36.6°C), volunteered to sit for a prolonged period while measurements were taken. She sat on all of the cushions and chairs in the same procedures.

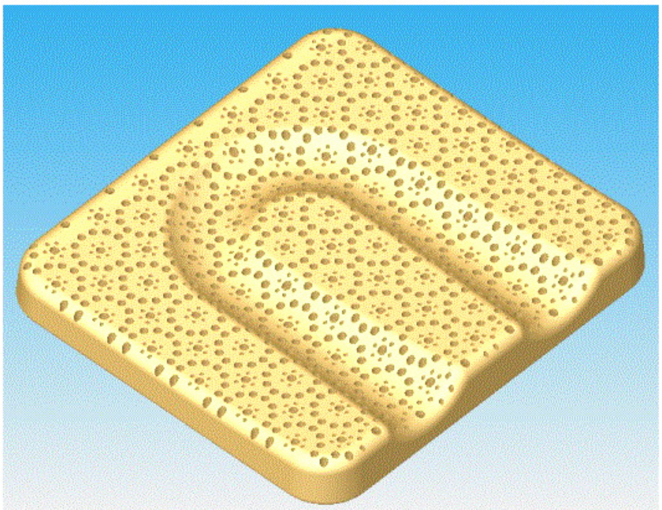


Figure 1. Elastone has been shown to have good elasticity and to be light of weight. Heat is easily ventilated through communicating pores. The shape is contoured to support a larger buttock area. (Top view)

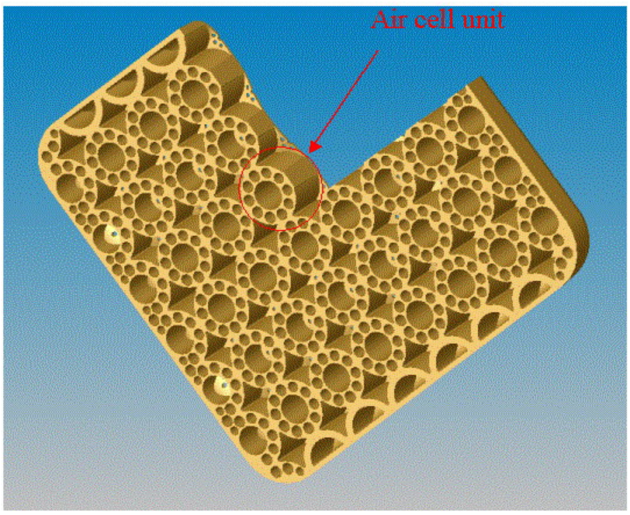


Figure 2. Elastone consists of multiple air cell units with communicating pores between the cells. (Bottom view)

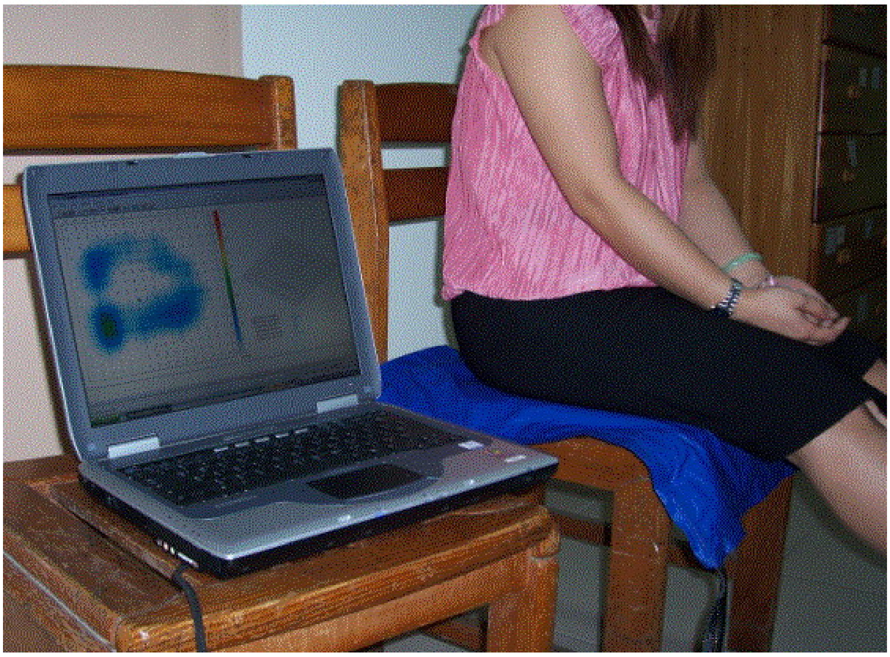


Figure 3. The pressure was measured by an FSA pressure monitor system. A cellular force plate was placed between the buttocks and either the cushions or the chair seats. The real time pressure distributions of the buttocks were automatically imaged in the monitor system.

Figure 4. During the eight-hour sitting period, the temperature of the buttocks was measured by a body surface thermometer (HP Omni Care CMS 24) with the sensor plate at the midpoint of the buttocks. The volunteer remained seated in a comfortable and quiet sitting for 8 hours on each of the selected cushions and seats in a controlled environment (22°C).

Unrelieved pressure of the buttocks is a critical factor in the development of pressure sore. Static axial pressure less than 32 mm Hg is assumed to be safe by many clinicians.[21] We found that all of the cushions analyzed in this study were more effective in relieving pressure than regular chair seats. In the present study, the average peak pressure of the Elastone cushion ranged from 50% to 80% lower than that of spongy and wooden chairs. It was 43% lower than the air-filled villous cushion, and was 34% lower than gel-filled and foam cushions. In contrast to the wooden chair, both the Elastone and ROHO cushions had larger total contact areas and lower pressure distribution over the ischial tuberosities than gel-filled cushions, foam or the spongy seats. That result was mostly in agreement with previous comparative studies of cushions, which evaluated pressure relief at the area of bony prominence.[5-9] Technical modifications of the pressure characteristics and thickness of foam may improve some aspects of pressure resistance.[12,22] The characteristics of stiffness and contoured surface supported their effectiveness in reducing pressure, which confirms previous studies.[7-9,16,18] The material and air cell structure of the Elastone cushion modifying the stiffness of cushion and accounts for the better pressure reduction and lower heat accumulation between the Elastone and ROHO cushions in this study.

Few studies of thermal properties of cushions have been conducted. Shvartz et al demonstrated that during prolonged sitting, the temperature of skin in contact with the seat increases greatly; they also reported that the skin temperature increases subjectively in response to discomfort.[19] Ferrarin et al studied the thermal conduction during contact with different wheelchair cushions; they found that flat-surface foam and air-filled cells exhibited higher peak temperatures than bubble-shaped surfaces.[20] A comfortable temperature is recognized to be below 32 ℃ for humans.[23] When the temperature is maintained below 34℃, approximately 5% of people might feel hot or discomfort; however, the majority of people usually feel more discomfort if a temperature of more than 35℃ is maintained.[24] In the present study, the Elastone cushion maintained the most comfortable temperature, never rising to more than 29℃. The multiple pores, which communicate with the air cells of the Elastone cushion, was effective in dissipating heat and minimizing temperature even during a long period of sitting. The gel-filled cushion maintained a comfortable temperature below 32℃ during two hours of sitting, and then gradually increased to a maximal temperature of 34℃ during the third hour. In contrast, we found that the air-filled ROHO, foam cushion and regular chair seats maintained a high temperature.

There were some limitations in this study. For example, we only studied one subject, and only two properties were used as the differential criteria for the various cushions. Further study is needed to quantify the effects of the Elastone cushions and/or other cushions with more properties, such as shear force, hemodynamics and subjective comfort, among different populations.

Despite the limitations, our results still demonstrated that temperature minimization was as important a factor as pressure relief for the selection of cushions. In addition, this study found that an average of two hours and/or a maximal duration of three hours in the measurements of temperature were sufficient to detect the thermal responses after cushion contact. In conclusion, the Elastone cushion had more advantages in terms of both pressure relief and temperature minimization than the other cushions studied. This result may be clinically valuable to pressure sore prevention and subjective comfort for wheelchair users.

ACKNOWLEDGMENT

We thank Professor Cheng, CK for his assistance.

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新型固態矽膠墊對臀部減壓及降溫之效果

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目的：本研究探討新型固態矽膠墊對臀部減壓及降溫之效果。

方法：本研究收集市場上常見之木椅、布面沙發椅、塑膠布面沙發椅及眞皮沙發椅等座椅以及常見之減壓座墊包括海綿墊、ROHO 氣墊、流體力學膠體墊及新型固態矽膠墊等椅墊，測量臀部受壓處壓力分佈、三次最大壓力和平均最大壓力，以及在 22℃環境室溫下連續 8 小時測量臀部受壓處溫度及時間變化曲線。

結果：結果顯示常用之具海綿墊之沙發椅均可減少臀部壓力，但臀部的溫度均較高。固態類矽膠墊平均最大壓力少爲 39.7 mmHg，減壓效果最佳，其次是海綿墊及流體力學膠體墊，平均最大壓力爲 60.3 mmHg，ROHO 氣墊平均最大壓力爲 69.3 mmHg，減壓效果尚可。但海綿墊及 ROHO 氣墊，臀部溫度會快速達到 35^{o}C 以上，會有不舒服的感覺。就溫度觀點而言，固態類矽膠墊溫度至 29^{o}C 上昇不高表現較佳，其次是流體力學膠體墊溫度至 33.8^{o}C，ROHO 氣墊溫度至 35^{o}C。

結論：就壓力和溫度雙方面的觀點，新型固態類矽膠墊在壓力及溫度的表現佳，提供適度的降低壓力及穩定的溫度，爲適當的座墊選擇。（台灣復健醫誌 2010；38(4)：215 - 222）

關鍵詞：減壓墊(cushion)，壓力(pressure)，溫度(temperature)，固態矽膠墊(gelatinous elastomers)，氣細胞(air cell)，溫度計(thermometer)，FSA 壓力監測系統(FSA pressure monitor system)

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