INFLUENCE OF DIFFERENT TYPES OF WHEELCHAIR CUSHIONS FOR PRESSURE ULCERS IN VIEW OF THE EXPERIMENTAL APPROACH

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ABSTRACT

It is well-known that improvements in seat comfort are needed as a medical solution to prevent pressure ulcers. In recent years, pressure ulcers have become an increasing social and medical issue and manufacturers are trying to respond appropriately for better solutions. The contact interaction between human buttock-tissue and seat cushion is an important factor in users’ sense of comfort. In this study, an approach by experimental method with pressure mapping (TexiMat) will be analyzed for eight different cushions in the aim to compare their behaviors in sitting position. The comportment of buttocks/cushions model was validated by experimental data. The main purpose of this article is to study the influence of material properties contributions on cushions and their capacities to reduce pressure distribution by improving the ability to prevent pressure ulcers. This study may help to choose different types of cushions as well as the thickness of the cushions for patients and user’s wheelchair to prevent pressure ulcers.

KEY WORDS

Wheelchair, cushions, pressure distribution (PD), pressure ulcer (PU), buttocks, ischial tuberosities (IT).

1. Introduction

Pressure ulcers (PU) occur due to pressure applied to the soft tissue resulting in completely or partially obstructed blood flow to the soft tissue [1, 2]. PU are areas of injury to the skin and underlying tissue muscles. The people with disabilities, wheelchair users daily, the elderly and the obese who used wheelchairs for long time can increase risk of PU. This depending in part by the high pressure and the stress distribution on their buttocks [3-5]. According to the report of the World Health Organization (WHO) in 2008, there was an estimation of 650 million disabled people around the world and about 10% of them need to use wheelchairs for their daily life [6]. The treatment cost of PU may be up to 12500 € in United Kingdom [7]. This cost may range from $2000 to $30000 per PU in the United States and it consumes an amount of about $ 1.3 billion per year of US health care system [8]. Brienza et al, [4] have shown the relation between PU incidence and high contact pressure at the buttocks/seat cushion interface for elderly wheelchair users. Several studies using numerical simulations method have been published comparing the mechanical properties of the wheelchair cushions, as well as the thickness of the cushion, changing form design, the patient's body balance posture when sitting. From these studies, [9-14] showed the distribution pressure at the surface buttocks/cushion and aims to prevent PU. For people with disabilities, wheelchair users PU appear often in the skin located over the ischial tuberosities (IT) [15] where focus the most part of the patient body weight [16]. Therefore, many studies appear to reduce the weight of stresses in the area of IT by including different varieties of wheelchair cushions models on the market [9, 17]. There are many different types of wheelchair cushions such as water, foam, gel, air, and viscoelastic cushions. These types of materials have different properties and advantages for the improvement of body balance, PU prevention, comfort, cushion shape, physiology of skin and the capacity to reduce friction [3, 9, 18]. Several methods exist aiming to evaluate the body comfort and the capacity to prevent PU for patients. The methods such as measuring the PU at the surface of the buttocks/cushions [19, 20], distributed temperature measurement at the surface of the cushion [21], as well as evaluating the performance of the cushions based on the type of tissue buttocks deformation [22]. Still lack a regulation on the critical pressure value at which PU can be developed. According to the general recommendations preventing PU, we must find the possibility to reduce the pressure at the surface of the buttocks [23].
The objective of this study is to quantify by using the TexiMat (pressure mapping) the pressure distribution (PD) at the surface buttocks/cushions for eight different commercial cushions. Moreover, we compare the results obtained among these cushions in the aim to classify their performance helping users to improve comfort, decrease pressure and preventing PU. The results will help to show the utilities of the pressure recording system in the interface of buttocks/cushion for wheelchair users and help to select a suitable cushion to prevent the risk of PU. The first step of our study was the comparison between different cushions developed by industry. The next step will be more original and will consider the modelization and simulation of materials in the aim to improve the future of cushions in relation with manufacturers. The numerical method of simulation will permit to decrease the number of experimentation (only for the model validation) and to propose a new kind of cushions including their shapes and materials properties etc…

2. Subjects and Methods

In this study, a healthy male participated in the experimentation. His principal characteristics are summarized in Table 1. The subject was informed by the nature, purpose and duration of the study.

Table 1: Anthropometric characteristics of the subject.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Weight (kg)</th>
<th>Age (year)</th>
<th>Size (cm)</th>
<th>IMG (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>75</td>
<td>34</td>
<td>173</td>
<td>21.69</td>
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The subject was installed in a wheelchair respectively with eight types of cushion included for each try a pressure mapping system. We measured the PD at the interface after sitting one minute on each wheelchair cushion by focusing on the PD recording at the buttocks/cushion interface for wheelchair cushions users. The experimentation have been done at the center “Fondation Garches” [24] of the hospital Raymond Poincare. The name and characteristics of the cushion used are described as below (Figure 1):

- **Cushion 1 (C1)**: The honeycomb cushion thermoplastic polyurethane (TPU) “Stimulite” was manufactured by Supracor company (USA), with the size of 400x460x72.
- **Cushion 2 (C2)**: The gel and firm foam cushion by JAY J3, with the size of 400x440x75.
- **Cushion 3 (C3)**: The 100% foam polyurethane by JAY, with the size of 400x420x40.
- **Cushion 4 (C4)**: The triangle air cushion by VICAIR, with the size of 450x520x100.
- **Cushion 5 (C5)**: The air cushion divided into two chambers which has shape fitting technology of Roho group, (The Roho Group, Inc., 100 N. Florida Avenue, Belleville, IL 62221-5429, USA), with the size of 440x470x95.
- **Cushion 6 (C6)**: The polyurethane foam by Supracor Company (USA), with the size of 380x480x85.
- **Cushion 7 (C7)**: The gel plaque of HNE medical, with the size of 380x390x10.
- **Cushion 8 (C8)**: The polyurethane foam of HNE medical with size: 410x410x66.

A sensor seat of the “TexiMat” pressure measurement system is 60 cm x 60 cm in size and consists of 32 pixels x 32 pixels. The data is collected, stored, analyzed and displayed on a personal computer by the TexiMonitor software [25]. The sensor included 32x32 pixels and permit to record the pressure distribution on the buttocks/cushions at 1024 points.
3. Results

The results obtained from experiments based on TexiMonitor software with connected a PC for eight different types of wheelchair cushion are shown in figure 2 and figure 3. In figure 2 the PD of two wheelchair cushions are shown for example (C1 and C3). We can observe the variability of the PD according to the property and characteristics of each cushion. The PD results obtained for all cushions showed that the maximal values of pressure is concentrated respectively in IT (the high pressure value obtained), great trochanter and the lower value at coccygeal regions.

![Figure 2. The pressure distribution at the interface buttocks/cushions of two wheelchair cushions.](image)

When comparing the behavior of the different cushions, our results showed the smallest value in air cushion (C5). The ability PD using C5 is uniform across the entire surface of the buttocks. C7 with the gel plaque of HNE present the high value of pressure in comparison to others (Figure 3). The result can be explained by his smallest thickness.

![Figure 3. The pressure distribution at the interface buttocks/cushions of eight wheelchair cushions.](image)

4. Discussion

Use pressure measurement system at the interface of buttocks/cushions is very useful for evaluating the mechanical properties of different kinds of wheelchair cushions and help to predict the possibility to decrease pressure ulcer by using the appropriate cushion. Among eight wheelchair cushions analyzed in this study, air cushion dual compartment (C5) and honeycomb cushion (C1) displaying the best mechanical properties for the distribution of pressure presenting the lower values in comparison to the others. Respectively, 21 kPa and 21.41 kPa for C5 and C1 and 24.26 kPa (C2), 24.08 (C3) kPa and 23.81 kPa (C4). The biggest value of PD is observed for C7 52.5 kPa. Concerning C6 and C8, they have the intermediate values.

The role of wheelchair cushion is distributed and reduces pressure at the interface buttocks/cushion aimed against the risk of development of pressure ulcers. Many studies were reported by Gutiérrez et al. [26], Gil-Agudo et al., [3], Tamimoto et al., [16] and Ferrarin et al., [18] which pointed out the specific value of the PD on the buttocks and cushion. Indeed, the pressure values obtained in the study [3] is 27 kPa with low-profile air cushion, 26.7 kPa with high-profile air cushion and 24.06 kPa with gel and firm foam cushion. The difference between our tested cushion values and the authors [3] can be explained by the material property characterizing is cushion. Gutiérrez et al. [26] showed that the value of pressure at the interface when the patient is sitting without cushion (118.17 kPa) and with cushion (24.03 kPa). Using the cushion, the results obtained by the authors [26] are next to C3 in our study but more important than those obtained by C1 and C5. The most important parameter can be the material property differences between the cushions used in our study and biography. In fact, good materials help to reduce risks of PU and increase the daily life of patient.

5. Conclusion

The wheelchair users have the possibilities today to use different cushion depending on the level of injuries. The material property of each cushion can impact directly the increase or decrease of stresses on the sitting area. Based on the results obtained from the 8 wheelchair cushions tested we can conclude that C1 and C5 are two types of cushion capable to reduce pressure improving the daily life of users.

In the next step of this study, we will perform the impact of different body posture of users to test and evaluate the PD. The results will help us to optimize the body balance of users improving their daily life.

References


