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COMFORT EVALUATION IN THE SEATED POSITION: POSTURAL VARIATION AS A MEANS OF PROMOTING HEALTH AMONG WHEELCHAIR USERS

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ABSTRACT

The prolonged permanence in the sitting posture in a wheelchair, without frequent postural change, favors the development of pressure injuries, back discomfort, among other health problems. The aim of this study was to evaluate comfort of wheelchair users, considering the postural variation in the sitting position. The research is characterized as theoretical-applied, descriptive and carried out under the quantitative paradigm. Sixty-four subjects participated in the study, divided into two groups: Wheelchair Group and Control Group. Comfort was evaluated at 90°, 100°, 110° and 120° inclination angles of the backrest and footrests of an experimental chair. The results did not show significant differences in the perception of comfort between the two groups. The 100° and 110° angles showed the highest levels of comfort. It is believed that the presence of mechanisms for postural variation in the wheelchair may assist in the comfort and health of wheelchair users considering the decrease in pressure and reduction of back pain/discomfort.

KEYWORDS: Sitting posture; Comfort; Wheelchair users; Health.

1. INTRODUCTION

The wheelchair is an assistive technology that promotes autonomy and social inclusion for people with reduced mobility, as it breaks the mobility limitations imposed by the body's inability to walk. According to Costa et al. (2010), the wheelchair provides such independence and freedom that it is considered by individuals with spinal cord injury as their own legs. Because it is essential for performing daily activities and integrating into society, these users use the wheelchair for several hours every day, spending most of their time in a seated position.

However, Basso's research (2013) pointed out that wheelchair users are dissatisfied with the posture imposed by the wheelchair, the comfort of the backrest, and back pain. Moraes and Pequini (2000) explain that in a seated posture, the abdominal muscles tend to relax more, and the spine tends to curve, resulting in symptoms of pain. In this sense, Iida and Guimarães (2016) point out that an inadequate angle of the seat/backrest increases the risk of the user experiencing pain in the dorsal muscles. Moraes and Pequini (2000) also add that sitting posture for long periods hinders the functioning of internal organs, such as the digestive and respiratory systems. According to Coury (1994), prolonged sitting in this position reduces blood circulation in the lower limbs, which can lead to edema in the ankles and feet.

For people with spinal cord injuries, especially those who do not have sensation, prolonged sitting without frequent postural changes increases the risk of developing pressure ulcers. Huet and Moraes (2003) explain that sitting for a period of 10 to 15 minutes without any postural changes causes the skin capillaries under the ischial tuberosities to close, leading to skin necrosis, followed by a burning sensation under the ischium and then over the trochanters. According to Costa et al. (2005), the development of a pressure ulcer can vary from 24 hours to 5 days. However, depending on the stage of the skin lesion and the treatment, healing can be very slow, taking several years to heal.

The quality of life of people who spend a lot of time seated depends significantly on the comfort they experience in this position (KROEMER; GRANDJEAN, 2005; MORAES, 2009). For Morse (1992), comfort is a state of well-being, which can occur at any stage of the health-disease continuum, and can be temporary (for example, temporary relief from pain) and long-term attainment, such as achieving health. To improve wheelchair comfort, in Barth et al.'s studies (2016), participants suggested adjustments to the angles of the wheelchair backrest. According to Rio and Pires (1999), the design of a wheelchair needs to promote

better sitting posture for long periods and allow for the adoption of a secondary posture for short periods, thus promoting the rest of the musculoskeletal segments that support the main posture.

Hunt et al. (2004) emphasize that wheelchairs are designed to meet the specific needs of their users and therefore have different characteristics, varying in material, shape, weight, durability, and cost. Generally, according to Teixeira et al. (2003), they are classified according to propulsion - manual or motorized. When conducting a brief search for wheelchair models available on major Brazilian internet product search sites, twenty brands of the product were found, ranging from 77 to 170 models in the manual wheelchair group, and 21 to 47 models in the motorized wheelchair group. However, when filtering the search for wheelchairs with a backrest tilt device, only three brands offered this feature, with 7 models of manual wheelchairs, two motorized, and one shower wheelchair. It was also observed that the configuration of these reclining models is more geared towards people without trunk control, as most have anatomical seats and backrests for postural adjustment. This highlights that in most wheelchairs, there is no design of a device of a backrest tilt, requiring the user to maintain the same posture for long periods and/or forcing them to leave the chair if they want to relieve back discomfort.

In this context, the general objective of the study was to evaluate the comfort of wheelchair users according to postural variation in the seated position. The specific objectives consisted of verifying if there is a significant difference in comfort perception between wheelchair users and the control group; and identifying the angles of backrest tilt and footrest support that promote greater comfort.

[5] Buscapé - www.buscape.com.br; Compare Preços - www.compareprecos.com.br; Zoom - www.zoom.com.br

2. MATERIALS AND METHODS

This article is an excerpt from the author's dissertation (BARTH, 2017) and is part of the research macro-project "Development of products and ergonomic adaptations for the wheelchair," under the CEP 49410815.2.0000.5348, funded by the Foundation for Support of Research in the State of Rio Grande do Sul (FAPERGS). The research is of a theoretical-applied nature, descriptive in character, and conducted under the quantitative paradigm.

The sample was characterized as non-probabilistic convenience sampling. The study involved 64 subjects, adults of both sexes, divided into two groups. In the Wheelchair User Group, 31 volunteers from the Association of Spinal Cord Injured Individuals of Rio Grande do Sul (LEME) participated, and in the Control Group, 33 volunteers affiliated with Feevale University participated, both located in Novo Hamburgo, RS. Regarding the participants' profiles, the Wheelchair User Group consisted of 26 male subjects and 5 female subjects, with a mean age of 39.2 (11.6) years; in the Control Group, 9 male subjects and 24 female subjects participated, with a mean age of 25.3 (6.1) years.

For the experiment, an experimental wheelchair was fabricated, which presented variation in the tilt of the backrest and footrest at angles of 90°, 100°, 110°, and 120°, with the seat parallel to the ground. The prototype was manufactured by the company Herval, from Dois Irmãos (RS), which is a partner of the research macro-project. The experimental wheelchair is illustrated in Figure 1.

Figure 1: Prototype of the experimental wheelchair

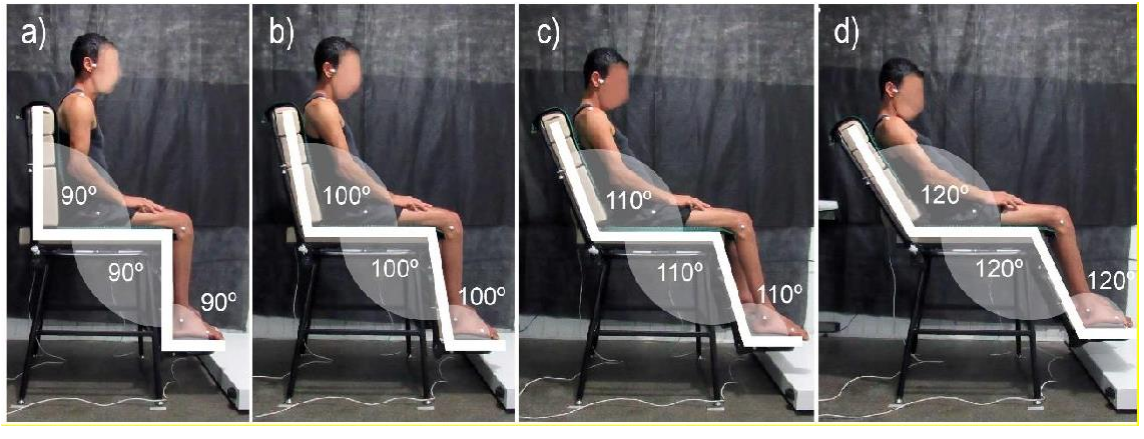
Source: the authors

The definition of the angles of inclination of the backrest and footrest of the experimental wheelchair was based on the research of Dudgeon and Deitz (2013), Kroemer and Grandjean (2005), Teixeira et al. (2003), and Engström (2002). The dimensions of the wheelchair encompass the 5th to 95th percentiles, recommended by Panero and Zelnik (2011). The backrest and seat are composed of foam cushions with a density of 50 kg/cm3, covered with 100% PVC fabric. It is worth mentioning that the density of 50 kg/cm3 is the minimum density for seats recommended by Technical Note 060/2001 from the Ministry of Labor and Employment (BRASIL, 2001), as this was the only reference found for foam density in chairs.

Chaffin et al. (2001) and Iida and Guimarães (2016) suggest a slight seat recline of up to 5° to prevent the body from sliding forward. However, since one of the main objectives of Barth's master's research (2017) was the evaluation of pressures on the seat and backrest during postural variation, it was decided to keep the seat of the experimental wheelchair parallel to the ground, as the angle of inclination could influence the pressure exerted by the ischial tuberosities on the seat surface.

The instrument used to assess comfort was a visual analog scale. This scale, as prescribed by the Macroergonomic Design method (FOGLIATTO; GUIMARÃES, 1999), is 15 centimeters in length, and the response can range from 0 to 15, according to the respondent's perception. On the left end of the scale, there is the negative value, and on the right end, the positive value. Participants marked with an "X" on the line corresponding to their level of comfort/discomfort. To generate the item weight, the locations marked by the participants were measured with a ruler. As a data collection procedure, participants from both groups (Wheelchair Users and Control) remained seated for 5 minutes in each position of inclination of the angles of the backrest and footrest of the experimental wheelchair, as shown in Figure 2.

Figure 2: Comfort assessment in the experimental wheelchair according to the angle of inclination of the backrest and footrest



Source: the authors

a) Evaluation in the seated position at 90°; b) Evaluation in the 100° position; c) Evaluation in the 110° position; d) Evaluation in the 120° position.

The period of 5 minutes is recommended by Iida and Guimarães (2016) for seat comfort evaluations, who mention that long-term evaluations (2 to 3 hours) do not vary much after this initial 5-minute period. After remaining seated for 5 minutes in the 90° position of the experimental wheelchair, the participant was asked to mark their comfort level on the 15 cm line corresponding to the 90° evaluation. Then, the backrest and footrest inclination of the experimental wheelchair were adjusted to 100°, and another 5-minute wait was observed before asking the participant to mark their comfort on the line corresponding to the 100° evaluation. This same procedure was applied to the other two inclinations (at 110° and 120°), always respecting the 5-minute interval between each adjustment.

An Icel brand hygrometer, model HT 7100, was also used to monitor the room temperature during data collection, as this is an important variable to ensure thermal comfort in the study locations. According to Iida and Guimarães (2016), thermal comfort is delimited between 20°C and 24°C, and may vary between 25°C and 28°C in tropical countries. Thus, the ambient temperature of the rooms where data collection took place was controlled between 21°C and 25°C. The hygrometer was placed at a maximum distance of 50 cm from the experimental wheelchair, i.e., very close to the participants.

For data analysis, SPSS-22.0 was used, with a significance level of 0.05. Descriptive statistics were performed, observing the arithmetic means and standard deviations. Kolmogorov-Smirnov tests, Student's t-test, and One-Way ANOVA with Tukey's HSD post hoc test were used.

4. RESULTS AND DISCUSSION

The Table 1 presents the evaluation of subjective comfort sensation from both groups at each inclination of the experimental wheelchair.

Table 1: Comfort Sensation for Both Groups at Different Inclinations of the Experimental Wheelchair.

GRUPS	**90°**	**100°**	**110°**	**120°**
WHEELCHAIR	6,8 b	10,5b	9,4 b	8,0 c

	(4,0)	(2,9)	(3,2)	(4,0)
CONTROL	8,4 (3,5)	9,8 [c] (2,8)	9,5 (2,4)	7,5 [c] (3,6)

Source:Barth (2017)

No significant differences between the groups (WHEEL and CTRL).
[b] Significant differences between 90° and 100°/110°.
c Significant differences between 100° and 120°.

In comparing the groups at inclinations of 90°, 100°, 110°, and 120°, no significant differences were found, indicating that reduced sensitivity due to spinal cord injury or other pathology does not interfere with comfort perception when compared to individuals with preserved sensitivity. In comparing the different inclinations of the experimental wheelchair, significant differences in subjective comfort sensation were found at all inclinations for the Wheelchair User Group. For the Control Group, significant comfort differences were observed only between inclinations of 100° and 120°. Participants in both groups perceived higher comfort levels at inclinations of 100° and 110°. These findings are consistent with suggestions by Iida and Guimarães (2016) that a slightly reclined seated position, at an angle of 95° to 110° between the backrest and seat, is less fatiguing as it minimizes muscle efforts and increases comfort. Tests conducted by Andersson et al. (1974, cited in NORDIN; FRANKEL, 2008) observed that with a backrest inclination of 100°, with or without lumbar support, pressure on the third lumbar disc of the spine was reduced compared to a 90° posture.

However, Kroemer and Grandjean (2005) suggest that better conditions for reducing pressures on intervertebral discs and muscle activities occur when the backrest inclination relative to the seat is between 110° and 120° to the horizontal. They argue that backrest inclination allows significant transfer of upper body weight to the support, reducing efforts of the spine musculature and on intervertebral discs. Nevertheless, as observed in Table 1, comfort index at 120° was lower compared to angles of 100° and 110°. It's believed that the absence of a headrest may have influenced comfort perception at this inclination angle, as several participants in both groups reported discomfort in the cervical region while maintaining an isometric head position during the evaluation period (5 minutes). In such cases, when the inclination exceeds 30°, Panero and Zelnik (2011) recommend the use of a headrest, which can be a separate element or an extension of the backrest itself.

Additionally, the absence of slight seat recline in the experimental wheelchair may have also influenced participants' comfort perception, as some participants in the Wheelchair User Group, specifically those without sensation in the lower limbs, reported feeling like they were sliding forward on the seat of the experimental wheelchair. Therefore, Chaffin et al. (2001) and Iida and Guimarães (2016) recommend a slight seat recline of up to 5°, which facilitates backrest usage and prevents body sliding on the seat. According to Nordin and Frankel (2008), additional backrest inclination should be accompanied by a corresponding increase in seat inclination.

Observing Table 1, it's evident that, for participants in the Wheelchair User Group, comfort at the 90° inclination was the only one below the mean of 7.5 on the visual analog scale (intersection point between positive and negative values), therefore the most uncomfortable according to wheelchair users' perception. Engström (2002) states that adopting a 90° seated posture is considered appropriate ergonomically for workplaces such as offices and schools, but most people sit in this position only for short periods. In comparison to a horizontal position, Iida and Guimarães (2016) note that sitting requires muscular activity from the back and abdomen, as well as 3 to 10% higher energy consumption. This indicates that an upright 90° posture demands more energy consumption than angles with greater backrest recline.

In this context, it's worth mentioning Moraes (2009), who concludes that to maintain a seated posture for long periods, it's necessary to continuously alternate between a set of natural and healthy positions. Therefore, this requires a wheelchair that allows the user to dynamically adopt this range of postures (LUEDER, 2003) through repositioning features such as tilt and seat recline (DING et al., 2008). Iida and Guimarães (2016) also suggest that the backrest should be mobile, allowing the person to recline backwards, periodically relieving fatigue.

However, designing reclining backrests in wheelchairs requires attention to the specific needs of individuals with reduced mobility, such as those with spinal cord injuries, where the height of the spinal cord injury influences the individual's trunk control. Lower backrests are suitable for wheelchair users with trunk control as they facilitate upper body movements when propelling the wheelchair. However, Nordin and Frankel (2008) caution that a too-low backrest provides inadequate trunk stability.

[6] O *tilt* em cadeira de rodas consiste em variar a orientação do sistema de suporte do assento no plano sagital, porém, mantendo do ângulo entre assento e encosto, bem como entre assento e suporte de pernas (WAUGH; CRANE, 2013).

The design of reclining backrests in manual wheelchairs for users with greater motor control should include a retractable system, i.e., one that can be sufficiently low to propel the wheelchair and extend to provide comfort in the reclined position. Regardless of whether it is a manual or motorized model,
If the wheelchair design includes a backrest recline exceeding 110°, it should incorporate a retractable headrest.

To improve backrest comfort, according to Iida and Guimarães (2016), adopting a concave shape is suggested, as flat ones made of rigid material are uncomfortable, directly contacting the bones of the spine. The authors also advise leaving a gap of 15 to 20 cm between the seat and the backrest due to the protrusion of the buttocks region.

It's important to be aware that, according to Chaffin et al. (2001), there is no ideal resting posture that can be comfortable for long periods, highlighting the need for the wheelchair to allow postural variations. When wheelchairs incorporate reclining and retractable backrests and footrests into their configuration, there will likely be more satisfied users with comfort, minimizing the incidence of spinal discomfort or pain.

5. CONCLUSIONS

This research aimed to evaluate the comfort of wheelchair users concerning postural variation in the seated position. The results showed no significant differences in comfort between the Wheelchair User and Control groups, indicating that reduced sensitivity does not interfere with comfort perception compared to individuals with preserved sensitivity.

The evaluation indicated higher comfort levels for angles of 100° and 110°. To enhance the comfort of individuals with reduced mobility in the seated posture, it is considered important for wheelchair designs to incorporate adjustable backrest and footrest reclining systems, minimizing fatigue imposed by the seated position. However, it is emphasized that if a backrest inclination close to or exceeding 110° is promoted, the wheelchair design should include a headrest to prevent tension on the muscles of the cervical region.

Finally, further studies are suggested on the influence of varying backrest and footrest inclinations of the wheelchair in preventing pressure injuries. To do so, it is necessary not only to measure pressures on the ischial tuberosities but also to consider the interference of postural variation on users' blood circulation. Furthermore, research that delves into the influence of different materials and technologies on user pressure on the seat should be

conducted, as well as considering backrest and footrest inclination angles.

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