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EVALUATION OF COMFORT IN THE SITTING POSITION: POSTURAL VARIATION AS A MEANS OF PROMOTING THE HEALTH OF 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 limit of locomotion imposed by the body that cannot walk. According to Costa et al. (2010), the wheelchair allows such independence and freedom that it is considered, by people with spinal cord injury, as their own legs. Because it is essential for carrying out daily activities and integrating into life in society, these users use the wheelchair for several hours and every day, remaining most of the time in a sitting position.

However, Basso's (2013) research 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) clarify that, in the sitting posture, the abdominal muscles tend to be more relaxed and the spine to curve, causing symptoms of pain. In this sense, Iida and Guimarães (2016)

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point out that an inadequate angle of the seat/backrest increases the risk of the user presenting pain in the dorsal muscles. Moraes and Pequini (2000) also add that sitting for long periods hinders the functioning of internal organs, such as the digestive and respiratory systems. According to Coury (1994), prolonged permanence in this posture reduces blood circulation in the lower limbs, which can generate edema in the ankles and feet.

For people with spinal cord injury, specifically those who do not have sensitivity, the time spent in the sitting position without frequent postural change increases the risk of developing pressure injuries. Huet and Moraes (2003) explain that remaining seated for a period of 10 to 15 minutes, without any postural change, causes the skin capillaries under the ischial tuberosities to close, causing an onset of necrosis in the skin, followed by a burning sensation under the sit bones and then over the trochanters. According to Costa et al. (2005), the development of a pressure ulcer can vary between 24 hours and 5 days. However, depending on the stage of the skin injury and the treatment, healing can take a long time, taking several years to heal.

The quality of life of people who spend a lot of time sitting 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 during any stage of the health-disease *continuum*, and can be temporal (e.g., temporary pain relief) and a state of long-term reach, such as the attainment of health. To improve comfort in the wheelchair, in the studies by Barth et al. (2016), the participants suggested that there be adjustments in the inclination angles of the wheelchair backrest. According to Rio and Pires (1999), the design of a wheelchair needs to favor the best sitting posture for long periods and that allows 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) point out that wheelchairs are designed to meet the specific needs of their users and therefore have different characteristics, which may vary in material, shape, weight, durability and cost. Generally, according to Teixeira et al. (2003), they are classified according to propulsion - manual or motorized. By conducting a brief search for wheelchair models available on the main Brazilian product search *sites*[5] on the internet, twenty brands of the product were found, ranging from 77 to 170 models in the group of manual chairs, and 21 to 47 models in the group of motorized chairs. However, when filtering the search for

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

wheelchairs with the presence of a backrest tilting device, only three brands presented this differential, with 7 models of manual wheelchairs, two motorized and one bath. It was also observed that the configuration of these reclining models is more aimed at people without trunk control, as most have an anatomical seat and backrest for postural adequacy. This shows that in most wheelchairs there is no design of a backrest reclining device, requiring the user to remain in the same posture for long periods and/or forcing him to get out of the chair if he wants to relieve back discomfort.

Based on this context, the general objective of the study was to evaluate the comfort of wheelchair users, according to postural variation in the sitting position. The specific objectives were to verify whether there is a significant difference in the perception of comfort between wheelchair users and the control group; and identify the angles of inclination of the backrest and footrest that promote greater comfort

2. MATERIALS AND METHODS

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

The sample was characterized as non-probabilistic by convenience. The study included 64 subjects, of legal age and of both sexes, divided into two groups. In the Wheelchair Group, 31 volunteers from the Association of Spinal Cord Injured People of Rio Grande do Sul (LEME) participated, and in the Control Group, 33 volunteers linked to Feevale University, both locations located in Novo Hamburgo, RS, participated. Regarding the profile of the participants, the Wheelchair Group was composed of 26 male and 5 female subjects, with a mean age of 39.2 (11.6) years; in the Control Group, 9 male and 24 female subjects participated, with a mean age of 25.3 (6.1) years.

For the experiment, an experimental chair was made that presents a variation in the inclination of the backrest and footrest at the angles of 90°, 100°, 110° and 120°, with the seat parallel to the floor. The prototype was manufactured by the company Herval, from Dois Irmãos (RS), which is a partner in the macro research project. The experimental chair is illustrated in Figure 1.

Figure 1: Prototype of the experimental chair

Source: the authors

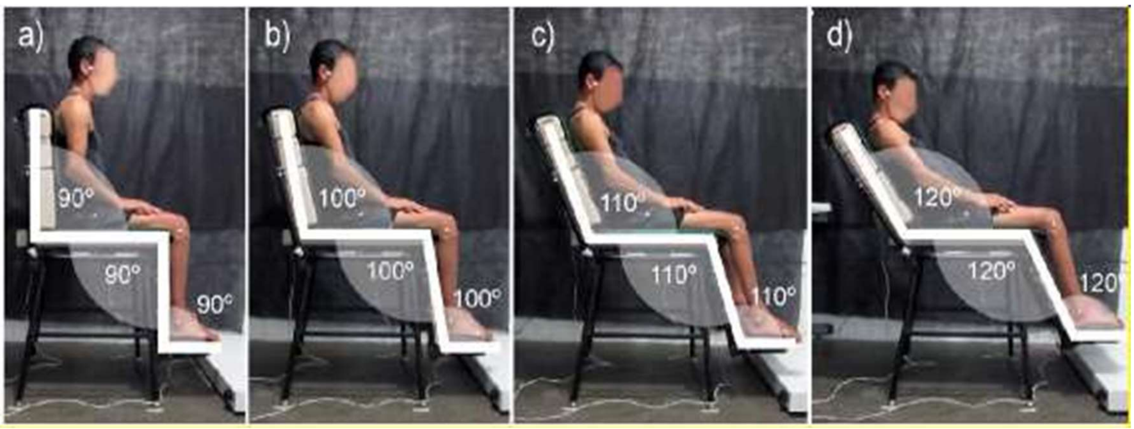
The definition of the inclination angles of the backrest and footrest of the experimental chair was based on the research of Dudgeon and Deitz (2013), Kroemer and Grandjean (2005), Teixeira et al. (2003) and Engström (2002). The dimensions of the chair include the 5th to the 95th percentile, recommended by Panero and Zelnik (2011). The backrest and seat are composed of a 50 Kg/cm3 density foam cushion, 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, of the Ministry of Labor and Employment (BRASIL, 2001), and this was the only reference found for foam density in chairs.

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

The instrument used to assess comfort was a visual analogue scale. This scale, as provided for by the Macroergonomic Design method (FOGLIATTO; GUIMARÃES, 1999), is 15 centimeters long, and the answer may vary from 0 to 15, according to the perception of the interviewee. At the left end of the scale, there is a negative value and, at the right end, a positive value. Participants marked with an "X" over the location of the line corresponding to their comfort/discomfort level. To generate the weight of the item, the places marked by the participants were measured with the help of a ruler.

As a procedure for data collection, the participants of the two 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 chair, as shown in Figure 2.

Figure 2: Evaluation of comfort in the experimental chair according to the angle of inclination of the backrest and footrest



Source: the authors

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

The 5-minute period is recommended by Iida and Guimarães (2016) for in-seat comfort assessments, who comment that long-term assessments (2 to 3 hours) do not vary much after this initial five-minute period. After sitting for 5 minutes in the 90° position of the experimental chair, the participant was asked to mark the comfort level on the 15 cm line corresponding to the 90° evaluation. Next, the inclination of the backrest and footrest of the experimental chair was adjusted to 100°, waiting again for 5 minutes and, subsequently, the participant was asked to mark his comfort on the line corresponding to the evaluation at 100°. 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 HT 7100 thermo-hygrometer was also used to monitor the temperature of the environment during data collection, since this is an important variable to ensure thermal comfort in the study sites. According to Iida and Guimarães (2016), thermal comfort is limited between 20°C and 24°C, and can vary between 25°C and 28°C in tropical countries. Thus, the ambient temperature of the rooms where the collections took place was controlled, between 21°C and 25°C. The thermo-hygrometer was placed at a distance of a maximum of 50 cm from the experimental chair, that is, 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 arithmetic means and standard deviations. The Kolmogorov-Smirnov test, Student's t-test, and One-Way ANOVA with Tukey's HSD Post Hoc test were used.

3. Results and discussions

Table 1 presents the evaluation of the subjective sensation of comfort of both groups in each inclination of the experimental chair.

Table 1: Feeling of comfort for the two groups at the different inclinations of the experimental chair.

GROUPS	**90th**	**100th**	**110th**	**120th**
WHEELCHAIR USERS	6.8 [b] (4,0)	10.5 [b] (2,9)	9.4 [b] (3,2)	8.0 [c] (4,0)
CONTROL	8,4 (3,5)	9,8 (2,8)	9,5 (2,4)	7.5 [c] 3,6

Source: Barth (2017)

There were no significant differences between the groups (CADEIR and CONTR).

[b] Significant differences between 90° and 100°/110°.

[c] Significant differences between 100° and 120°.

In the comparison between the groups at the 90°, 100°, 110° and 120° inclinations, no significant differences were found, which indicates that the reduction in sensitivity, due to spinal cord injury or other pathology, does not interfere with the perception of comfort when compared to people with preserved sensitivity. In the comparison between the different inclinations of the experimental chair, for the Wheelchair Group, significant differences were found in the subjective sensation of comfort in all inclinations. For the Control Group, there were significant differences in comfort only between the 100° and 120° inclinations.

The subjects' perception of both groups showed higher levels of comfort at 100° and 110° inclinations. Corroborating these findings, Iida and Guimarães (2016) suggest that a slightly reclined sitting position, at an angle of 95º to 110º between the backrest and the seat, is less tiring, as it minimizes muscle effort and increases comfort. In the tests carried out by Andersson et al. (1974 apud NORDIN; FRANKEL, 2008) it was observed that with a 100º inclination of the backrest, both with lumbar support and without, the pressure exerted on the third lumbar disc of the spine reduced when compared to the 90° posture.

However, Kroemer and Grandjean (2005) believe that there are better conditions for reducing intervertebral disc pressures and muscle activities when the inclination of the backrest in relation to the seat is between 110º and 120º in relation to the horizontal. The authors justify that the inclination of the backrest allows a significant transfer from the upper part of the body to the support, reducing the efforts of the muscles of the spine and the intervertebral discs. However, as can be seen in Table 1, the comfort index at 120° was lower when compared to the 100º and 110° angles. However, it is believed that the absence of a headrest may have influenced the perception of comfort at this angle of inclination, as several participants in both groups reported discomfort in the cervical to keep the head in an isometric position during the evaluation time (5 minutes). In cases like this, when the inclination is greater than 30°, Panero and Zelnik (2011) recommend the use of the headrest, which can come as a separate element or be an extension of the backrest itself.

In addition, it is believed that the absence of a slight recline of the experimental chair seat may also have influenced the participants' perception of comfort, since, specifically in the Wheelchair Group, some subjects without sensitivity in the lower limbs reported having the sensation of slipping on the seat of the experimental chair. Thus, Chaffin et al. (2001) and Iida and Guimarães (2016) recommend a slight recline of the seat of up to 5°, which facilitates the use of the backrest and prevents the body from sliding over the seat. For Nordin and Frankel (2008), an additional inclination of the backrest should be accompanied by the same increase in the inclination of the seat.

Table 1 also shows that, for the participants in the Wheelchair Group, comfort at the 90° inclination was the only one lower than the mean 7.5 of the visual analogue scale (point of intersection between positive and negative values), therefore the most uncomfortable in the perception of wheelchair users. Engström (2002) states that the adoption of the 90° sitting posture is considered an appropriate position, in ergonomic terms, for workplaces such as offices and schools, but most people sit in this position only for short moments. Compared to

[6] Tilt in a wheelchair consists of varying the orientation of the seat support system in the sagittal plane, but maintaining the angle between seat and backrest, as well as between seat and leg support (WAUGH; CRANE, 2013).

the horizontal position, Iida and Guimarães (2016) observe that in the sitting posture the body requires muscle activity of the back and belly, in addition to 3 to 10% higher energy consumption. This indicates that the 90° upright posture requires more energy consumption from the body than the angles with greater recline of the backrest.

In this context, it is worth mentioning Moraes (2009), who concludes that, in order to maintain the sitting posture for long periods, it is necessary to continuously alternate a set of natural and healthy positions. Therefore, this requires a chair that allows the user to adopt this range of postures dynamically (LUEDER, 2003), through repositioning features such as *tilt6* and seat recline (DING et al., 2008). Iida and Guimarães (2016) also suggest that the backrest should be mobile, allowing the person to recline back, periodically relieving fatigue.

However, designing reclining backrests in wheelchairs requires attention to the specificities of people with reduced mobility, such as in spinal cord injured people, where the height of the spinal cord injury must be considered, which influences the subject's greater or lesser trunk control. The lower backrests are suitable for wheelchair users who have trunk control, as they facilitate the movements of the upper limbs when propelling the wheelchair. However, Nordin and Frankel (2008) warn that very low support for the back does not provide stability for the trunk.

The reclining design of the backrest of manual wheelchairs for users with greater motor control must include a retractable system, that is, it can be low enough to be able to propel the wheelchair and extend to provide comfort in the reclined position. Regardless of the manual or motorized model, if the wheelchair project provides for a recline of the backrest above 110°, it must include a retractable headrest.

To improve the comfort of the backrest, according to Iida and Guimarães (2016), it is suggested to adopt the concave shape, as those with a flat shape and made with rigid material are uncomfortable, coming into direct contact with the bones of the spine. The authors also advise that an empty space of 15 to 20 cm be left between the seat and the backrest, due to the bulge of the buttock region.

It is important to be aware that, according to Chaffin et al. (2001), there is no ideal posture at rest that can be comfortable for long periods, which highlights the need for the chair to allow postural variations. When wheelchairs include in their configuration reclining and retractable backrests and footrests, there will also possibly be users who are more satisfied with comfort, minimizing the incidence of pain/discomfort in the spine region.

4. Conclusions

This research aimed to evaluate the comfort of wheelchair users according to postural variation in the sitting position. The results showed that there were no significant differences in comfort between the Wheelchair and Control groups, indicating that the reduction in sensitivity does not interfere with the perception of comfort when compared to people with preserved sensitivity.

The evaluation pointed to higher levels of comfort for the 100° and 110° angles. Aiming at greater comfort for people with reduced mobility in the sitting posture, it is considered important that wheelchair designs include in their structure, backrest recline adjustment systems and footrest, minimizing the fatigue imposed by the sitting posture. However, it should be noted that, if a backrest inclination close to or greater than 110° is promoted, the wheelchair design must provide support for the head in order to avoid tension on muscles in the cervical region.

Finally, more in-depth studies are suggested on the influence of the variation of the inclinations of the backrest and footrest of the wheelchair on the prevention of pressure injuries. To this end, it is necessary not only to measure the pressures on the ischial tuberosities, but also to consider the interference of postural variation in the blood circulation of users. In addition, it is suggested that research be carried out to deepen the approach to the influence of different materials and technologies on the user's pressure on the seat, as well as the angles of inclination, backrest and footrest.

References

BARTH, M.; RENNER, J. S.; FERRO, B. H.; SOUZA, M.; WOLFF, B. G. Parâmetros de design ergonômico e de conforto para cadeira de rodas: um enfoque para o encosto. Anais do 18º Congresso Brasileiro de Ergonomia, Belo Horizonte, MG, 2016. 7 p.

, M. Parâmetros ergonômicos e de conforto para usuários de cadeira de rodas: um enfoque para saúde e inclusão social. 2017. 100 f. Dissertação (Mestrado em Diversidade Cultural e Inclusão Social) - Feevale, Novo Hamburgo-RS, 2017.

BASSO, C. R. Parâmetros ergonômicos de conforto para usuários de cadeiras de rodas. 2013. 58 f. Monografia (Trabalho de Conclusão do Curso de Design) — Feevale, Novo Hamburgo/RS, 2013.

BRASIL. Ministério do Trabalho e Emprego. Nota Técnica 060/2001, de 3 de setembro de 2001. Brasília: MTE, 2001. 9 p.

CHAFFIN, D. B.; ANDERSON, G. B. J.; MARTIN, B. J. Biomecânica ocupacional. Belo Horizonte, MG: Ergo, 2001. 579 p.

COSTA, M. P.; STURTZ, G.; COSTA, F. P. P.; FERREIRA, M. C.; FILHO, T. E.; BARROS, P. Epidemiologia e Tratamento das Úlceras de Pressão: Experiência de 77 Casos. ACTA Ortopedia Brasileira, São Paulo, v. 13, n. 3, p. 124-133, mai. 2005.

COSTA, V. S. P.; MELO, M. R. A. C; GARANHANI, M. L.; FUJISAWA, F. S. Representações sociais da cadeira de rodas para a pessoa com lesão da medula espinhal. Rev. Latino-Am. Enfermagem, v. 18, n. 4, 8 telas, jul.-ago. 2010.

COURY, H. J. C. Programa auto-instrucional para o controle de desconfortos posturais em indivíduos que trabalham sentados. 1994. 128 f. Tese (Doutorado em Educação) – Universidade Estadual de Campinas, Campinas, 1994.

DING, D.; LEISTER, E.; COOPER, R.; KELLEHER, A.; FITZGER-ALD, S. G.; BONINGER, M. L. Usage of tilt-in-space, recline, and elevation seating functions in natural environment of wheelchair users. Journal of rehabilitation research and development, v. 45, n. 7, p. 973, 2008.

DUDGEON, B. J.; DEITZ, J. C. Seleção da cadeira de rodas. In: TROMBLY, C. A.; RADOMSKY, M. V. Terapia ocupacional para disfunções físicas. São Paulo, 6. Ed. Santos: 2013. p. 487-509.

ERGSTRÖM, B. Ergonomic Seating: a true challenge. Germany: Posturalis Books, 2002.

FOGLIATTO, F. S.; GUIMARÃES, L. B. M. Design Macroergonômico de Postos de Trabalho. Enegep, v. 4, 16 p. 1999.

HUET, M.; MORAES, A. Medida de pressão sobre a pelve na postura sentada em pesquisas de ergonomia. Fisioterapia Brasil, v.4, n.6, p.438-44, nov./dez. 2003.

HUNT, P. C.; BONINGER, M. L.; COOPER, R. A.; ZAFONTE, R. D.; FITZGERALD, S. G.; SCHEMELER, M. R. Demographic and socioeconomic factors associated with disparity in wheelchair customizability among people with traumatic spinal cord injury. Arch Phys Med Rehabil., v. 85, p. 1859-64, 2004.

IIDA, I; GUIMARÃES, L. B. M. Ergonomia: projeto e produção. 3. ed. São Paulo, SP: Blücher, 2016. 850 p.

KROEMER, K. H. E.; GRANDJEAN, E. Manual de ergonomia: adaptando o trabalho ao homem. 5. ed. Porto Alegre, RS: Bookman, 2005. 327 p.

LUEDER, R. Ergonomics of seating: case for & against movement for its own sake. Humanics Ergonomics: Ergonomics consultants, oct. 2003. Disponível em: <http://www.humanics-es.com/rethinkingsitting.pdf>. Acesso em: 01 jul. 2015.

MORAES, A.; PEQUINI, S. M. Ergodesign para trabalho em terminais informatizados. Rio de Janeiro, RJ: 2AB, 2000. 117 p.

MORAES, H. S. Projeto conceitual de sistemas de assento para cadeira de rodas: uma abordagem sistemática. 2009. 143 f. Dissertação (mestrado em Design) — Programa de Pós-Graduação em Design, Universidade Federal do Rio Grande do Sul, Escola de Engenharia e Faculdade de Arquitetura, Porto Alegre, 2009.

MORSE, J. M. Confort: the refocusing of nursing care. Clinical Nursing Research., v. 1, n. 1,p. 91-106, 1992.

NORDIN, M.; FRANKEL, V. H. Biomecânica básica do sistema musculoesquelético. Rio de Janeiro: Guanabara Koogan, 2008.

PANERO, J.; ZELNIK, M. Dimensionamento humano para espaços interiores: um livro de consulta e referência para projetos. Barcelona, Espanha: Gustavo Gili, 2011.

RIO, R. P.; PIRES, L. Ergonomia: fundamentos da prática ergonômica. Belo Horizonte: Health, 1999.

TEIXEIRA, E.; SAURON, F. N.; SANTOS, N. S. B.; OLIVEIRA, M. C. Terapia ocupacional na reabilitação física. São Paulo: Roca, 2003.

WAUGH, K.; CRANE, B. A clinical application guide to standardized wheelchair seating measures of the body and seating support surfaces. Revised Edition. University of Colorado/Assistive Technology Partners Denver, Colorado, USA, Aug. 2013.