



## ERGONOMIC DESIGN AND COMFORT PARAMETERS FOR WHEELCHAIRS: A FOCUS ON THE BACKREST

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**Summary:** The wheelchair is essential for people with reduced mobility because it provides better living conditions, autonomy, and independence, contributing to their inclusion in society. These individuals spend a large part of the day in a seated position, making comfort a key requirement for using the wheelchair. However, one of the complaints from users is regarding the discomfort of the backrest. The general objective of this research was to establish ergonomic comfort parameters for the wheelchair backrest. This is a theoretical-applied research, descriptive in nature, with data analysis under the qualitative paradigm. The field of study was the Association of Spinal Cord Injured Persons of Rio Grande do Sul (LEME), in Novo Hamburgo, RS. A semi-structured interview was used as a research instrument. Seven participants took part in the research. They brought up issues related to the backrest, such as fabric deformation over time, lack of tilting devices, and backrest height. The wheelchair backrest structure needs redesign to improve posture and consequently the comfort, health, and quality of life of users.

**Keywords:** Wheelchair, Backrest, Comfort.

## 1. INTRODUCTION

Assistive technologies are great allies in the daily lives of people with disabilities. According to the Demographic Census of the Brazilian Institute of Geography and Statistics (IBGE, 2010), 13.3 million (6.95% of the population) reported having reduced mobility, including wheelchair users. For people with spinal cord injury and other people with reduced mobility, the wheelchair is a fundamental assistive technology for locomotion, helping people with disabilities participate in numerous activities, providing greater independence both at home and in the community (CHAVES et al.,

2004). The wheelchair allows such independence and freedom that, according to research by Costa et al. (2010), his legs.

Taking the place of the legs of people with reduced mobility, the wheelchair becomes fundamental in the daily lives of these users, who remain in a sitting position for long periods. Therefore, having a suitable and comfortable wheelchair is very important for the user's health. However, most wheelchairs are still quite lacking in terms of comfort. For Moraes (2009), the quality of life of people who spend a lot of time sitting depends significantly on the comfort they experience in this position. According to Abreu (2012), most people sit asymmetrically, which becomes a problem when the posture is maintained for long periods. According to research carried out by Basso (2013), wheelchair users are dissatisfied with their posture in the wheelchair, the comfort of the backrest and back pain.

In the sitting position, the body remains supported on surfaces such as the seat, back, chair arms, among others (DUL; WEERMEESTER, 2004). Sitting for long periods is harmful when the body posture is not changed with frequency. 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 necrosis to begin in the skin, followed by a sensation of burning under the ischia and then over the trochanters as the area of pressure increases with the separation of the soft tissues. In the case of wheelchair users without

sensitivity in this region and who remain in the same position for a long time, this pressure causes a pressure ulcer to develop in a short time. Depending on the degree of the skin injury, the healing time may be quite long. During this period, pressure on the injury site must be avoided, so the wheelchair user must avoid sitting.

Furthermore, sitting posture can bring other health problems. Moraes and Pequini (2000) mention the difficulty in functioning of internal organs, such as the digestive and respiratory systems; the abdominal muscles tend to slacken and the spine tends to curve. According to Coury (1994), in a sitting posture, the internal pressure of the intervertebral disc increases by 35% compared to a standing posture, generating changes in the musculoskeletal structures of the lumbar spine. Furthermore, according to the author, prolonged stay in this posture reduces blood circulation in the lower limbs and can cause edema in the ankles and feet.

In this context, the general objective of this research is to generate ergonomic design and comfort parameters for the wheelchair backrest. The specific objectives are centered on characterizing the profile of employees; investigate how the backrest causes discomfort in the spine and investigate possible solutions that will promote comfort in the backrest.

## 2. METHODOLOGY

This research is of a theoretical-applied nature, which through bibliographical collection and field research will generate knowledge for practical application in solving the problem. As for typology, the research is descriptive in nature. Descriptive research seeks to know and interpret, classify, explain, record and describe the facts that occur (MORAES; MONT'ALVÃO, 2012; PRODANOV; FREITAS, 2009). Data analysis and discussion will be carried out under the qualitative paradigm. The qualitative method seeks to understand the context in which a phenomenon occurs, allowing the observation of various elements in a small group (VÍCTORA et al., 2000).

The field of study was the Association of Spinal Cord Injured People of Rio Grande do Sul (LEME), in the city of Novo Hamburgo (RS). A semi-structured interview was carried out where a pre-established script was followed, seeking to identify, among wheelchair users, the discomfort factors caused by the backrest of the wheelchair. According to Minayo et al. (2005, p.91), the semi-structured interview combines open and closed questions where "the

interviewee has the possibility of discussing the topic in question without being tied to the formulated question”.

The analysis and discussion of the collected data took place using the triangulation method. According to studies by Marcondes and Brisola (2014), this method of analysis involves a *modus operandi* based on the preparation of the collected material and the articulation of three aspects to carry out the analysis: the empirical data collected in the research; dialogue with authors who study the topic in question; and situation analysis. According to Souza and Zioni (2003), the triangulation method allows “greater validity of the data and a deeper insertion of researchers in the context from which the facts, speeches and actions of the subjects emerge”.

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### 3. RESULTS

Seven wheelchair users were interviewed, three of whom were female and four were male. Table 1 shows the profile of each research collaborator, as well as whether they have ever had pressure ulcers.

**Table 1 – Profile of employees**

Collaborators	Gender	Age (years)	Height (m)	Weight (kg)	Chair time (years)	Lesão	Have you ever had pressure ulcers?
Collaborator 1	F	44	1,73	77	5 ½	C5 e C6	Si
Collaborator 2	M	37	1,75	68	7	T5	Si
Collaborator 3	M	39	1,69	69	5	T5 e T6	Si
Collaborator 4	F	54	1,60	64	12	Multiple sclerosis	N
Collaborator 5	M	33	1,90	87	6	spinal trauma	Si
Collaborator 6	M	30	1,72	58	7	T5 e T6	Si
Colaborad	F	34	1,53	3	8	Vírus HTLM1	N

F Source: Authors (2015)

In table 1 it is possible to observe that only two employees did not have pressure ulcers. However, it should be noted that, of those who had pressure ulcers,

some developed them in the hospital bed while recovering from the accident. When sitting in a wheelchair, pressure ulcers generally develop in the ischial tuberosities, in the sacrococcygeal region, in the popliteal region and in the plantar region (BAPTISTA, 2010). An adequate backrest can significantly influence the prevention of pressure ulcers. This prevention can occur through an adequate inclination of the backrest that reduces the pressure of these most affected regions on the seat, improving the distribution of the user's body weight in the wheelchair, promoting comfort and, mainly, aiding overall health.

Vergara and Page (2002) comment that the presence of some discomfort in the lumbar spine region causes a decrease in general comfort such that low back pain seems to be the most important for the relationship between comfort and discomfort in the sitting position. In order to improve backrest comfort, two employees suggest the presence of a tilt adjuster: “It would be nice to have an adjustment like a car seat so that it doesn't always stay in the same position.” (Employee 3); “The backrest should have three tilt positions and be more anatomical, following the curvature of the spine.” (Collaborator 4).

When discussing the inclination of the backrest to promote adequate posture, it is also necessary to take into account the good positioning of the pelvis. Kangas (2005) states that the pelvis is the main point of support with the support surface (the seat) and, therefore, the reference base on which the position and movements of the other segments of the body are located. For good pelvic positioning, the sitting position must favor spinal curves similar to those in the standing position, which influence the function of the upper limbs, visual alignment and physiological activities such as breathing, digestion and circulation (MORAES, 2009). According to Teixeira et al. (2003), the pelvis must be centered, level and in a neutral position.

Chaffin et al. (2001) argue that, compared to a standing posture, a sitting posture without back support, the total lumbar angle reduces by an average of 38°. Using a vertical backrest increases both the lordosis and the individual angles of the lumbar vertebral bodies. And with a backrest inclination from 90° to 110°, the authors identified a slight reduction in lumbar lordosis and, consequently, a reduction in posterior rotation of the pelvis.

Regarding the influence of the backrest angle on the positioning of the pelvis, Chaffin et al. (2001) clarify that in an average (erect) position, the center of mass is above the ischial tuberosities of the pelvis. In the backward leaning position, “less than 25% of the body

weight is supported by the legs and the center of mass is behind the ischial tuberosities" (CHAFFIN et al., 2001, p.358).

The presence of a backrest inclination adjustment device would be a very favorable way to promote health, as this would make it possible to relieve the pressure of the user's body on the backrest and seat of the wheelchair, improving blood circulation and, consequently, preventing the formation of pressure ulcers. Corroborating this statement, Dudgeon and Deitz (2013) comment that changes to the suspended backrest of the wheelchair may eventually be necessary in order to improve posture. They cite as examples the use of an adjustable or flexible suspended backrest, curved backrests, or side supports for additional support.

Employees also pay attention to the need for the backrest to be firm so that it does not give in and harm the posture of the spine.

*The backrest would be better if it were more rigid, because when I lean on it, the bars move together. I had a rigid chair, but there were a lot of parts to disassemble, and this was a problem when I wanted to take the chair in the car. [...] It would be better if there was a bar to make it firmer. (Collaborator 1)*

*I use a cushion on the backrest to keep it straighter, as the cloth sags. [...] The rigid back of monoblock chairs is better compared to common wheelchairs. (Collaborator 2)*

*The fabric starts to buckle and I shrink all over. I put a pillow to tighten it. [...] I had this pillow made. There is nothing like it for sale. [...] I had made a half-bent iron bar to make the center of the backrest firmer, but it caused a lot of discomfort on the back. (Collaborator 3)*

*In folding wheelchairs, like mine, the backrest is very soft, it gives way very easily and makes you bend over more. If you put something rigid in the back it would be fine. [...] In the monoblock there is an aluminum plate inside the backrest that you can place. (Collaborator 5)*

*If I didn't have this backrest, my back would hurt more, because my back keeps sticking [...]. I had my backrest made, I even have to have another one made that is more "firm" [...] Because this one is already a bit curved (worn). Without the backrest, your posture is very bad, so you stay*

*more straight. [...] The pain I feel in my back is more at night. (Collaborator 7)*

When analyzing users' expressions on the issue, it is possible to note the need for an adequate backrest to maintain good posture and consequently comfort. The material and the way wheelchair backrests are designed deform over time, causing the user's spine to adapt to the deformation, influencing comfort and damaging the spine. Figures 1 and 2 illustrate the backrests of two employees' wheelchairs, which became deformed over time. In one of them, the wheelchair user adapted a pillow with the aim of correcting his posture.

**Figure 1: Extended backrest of employee 5's wheelchair. Source: Authors (2015).**



**Figure 2: Cushion developed by collaborator wheels 5. Source: Authors (2015).**



According to Chaffin et al. (2001) the load on the lumbar spine in the sitting position is reduced when the back is adequately supported, especially when the backrest is inclined at an angle of  $110^\circ$  in relation to the horizontal. Thus, it is understood that, with the deformation of the wheelchair backrest, the positioning of the cervical spine is altered, resulting in discomfort.

Regarding the height of the backrest, two collaborators believe that lower backrests are more suitable: "A lower backrest is better, as it leaves movements freer. A higher backrest is limiting for taller people. Most people take lower backrests." (Employee 3); "A lower backrest is better for moving around, but for sitting still a higher backrest is better for supporting your back." (Collaborator 6).

According to Dudgeon and Deitz (2013, p.500), the "height of the chair back is based on the need for postural stability and freedom of movement of the arms for propulsion or other functions". The authors recommend a chair back height of 2-5 cm under the edge of the scapula, unlike sports chairs where the back height can be even lower. However, regarding the backrest of motorized chairs, the authors comment that the height may reach up to the middle portion of the scapula or up to the upper portion of the trunk and head.

Finally, it is observed that, through the results of the interviews, employees are dissatisfied with the comfort of the backrest, which points out as problems the material and the way in which the backrests are manufactured, which give way during use. of the wheelchair, making them uncomfortable and positioning the spine inappropriately. They also comment on the height of the backrest, where the lower ones favor the movement of the arms for propulsion, while the higher ones allow for more comfort.

Furthermore, they also suggest a device for adjusting the backrest inclination, allowing the body pressure to be redistributed. However, it is believed that more in-depth research is needed

on the influence of the backrest inclination on reducing pressure levels on the back and on the ischial tuberosities, in order to prevent the formation of pressure ulcers.

### 3. CONCLUSION

This research aimed to generate ergonomic and comfort design parameters for the wheelchair backrest. The answers, coming from users' opinions, may guide the redesign of these backrests. However, these results would not have been as reliable without the contribution of the users themselves. Thus, the importance of listening to the user to establish parameters to improve products stands out. And, in the same way, the relevance of an interdisciplinary team working on the redesign of assistive technologies, with complementary expertise in favor of the health and quality of life of this public, which still lacks innovations to help them daily and integrate them into society.

### 4. BIBLIOGRAPHICAL REFERENCES

- ABREU, Caroline Gomes Lopes de. **Análise de indivíduos hemiplégicos cadeirantes em assentos de diferentes densidades por meio da fotogrametria computadorizada**. 2012. 77 f. Dissertação (Programa de Pós-graduação em Engenharia Elétrica) — Universidade Federal de Uberlândia, Uberlândia, MG, 2012. Disponível em: <[http://www.bdttd.ufu.br/tde\\_arquivos/11/TDE-2012-05-29T094342Z-3032/Publico/d.pdf](http://www.bdttd.ufu.br/tde_arquivos/11/TDE-2012-05-29T094342Z-3032/Publico/d.pdf)>. Acesso em: 29 set. 2013.
- BASSO, Rafaela. **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. Disponível em: <<http://ged.feevale.br/bibvirtual/Artigo/ArtigoClaudiaBasso.pdf>>. Acesso em: 29 ago. 2013.
- CHAFFIN, Don B.; ANDERSON, Gunnar B. J.; MARTIN, Bernard J. **Biomecânica ocupacional**. Belo Horizonte, MG: Ergo, 2001. 579 p.
- CHAVES, E. A.; BONINGER, M. L.; COOPER, R.; FITZGERALD, S. G.; GRAY, D. B.; COOPER, R. A. Assessing the influence of wheelchair technology on perception of participation in spinal Cord injury. **Arch Phys Med Rehabil**. Vol 85, 2004.
- 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**, 18(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. Dissertação de doutorado. Faculdade de Educação, Universidade Estadual de Campinas, Campinas, 1994.
- 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, 5. Ed. Santos: 2005.
- DUL, Jan; WEERDMEESTER, Bernard. **Ergonomia prática**. 2.ed. rev. e ampl. São Paulo: Edgard Blücher, 2004. 137 p.
- HUET, Mariana; MORAES, Anamaria. 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. Disponível em: <[http://ergocenter.com.br/artigos/artigos\\_5/postura\\_sentada.pdf](http://ergocenter.com.br/artigos/artigos_5/postura_sentada.pdf)>. Acesso em: 14 jun. 2014.
- INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA (IBGE). **Censo demográfico 2010**. Disponível em: <[ftp://ftp.ibge.gov.br/Censos/Censo\\_Demografico\\_2010/Caracteristicas\\_Gerais\\_Religiao\\_De\\_ficiencia/tab1\\_3.pdf](ftp://ftp.ibge.gov.br/Censos/Censo_Demografico_2010/Caracteristicas_Gerais_Religiao_De_ficiencia/tab1_3.pdf)>. Acesso em: 07 set. 2014.
- KANGAS, K. **Seating for Task Perfomance**. In: 18th International Seating Symposium, Orlando, USA. 2002.
- MARCONDES, Nilsen Aparecida Vieira; BRISOLA, Elisa Maria Andrade. Análise por triangulação de métodos: um referencial para pesquisas qualitativas. **Revista Univap**, v. 20, n. 35, jul. 2014.
- MINAYO, M. C. S.; SOUZA, E. R.; CONSTANTINO, P.; SANTOS, N. C. Métodos, técnicas e relações em triangulação. In: MINAYO, M. C. S.; ASSIS, S. G.; SOUZA, E. R. (ORG.) **Avaliação por triangulação de métodos: abordagem de programas sociais**. 1. reimp. Rio de Janeiro, RJ: FIOCRUZ, 2005. 244 p.
- MORAES, Anamaria de; PEQUINI, Suzi Mariño. **Ergodesign para trabalho em terminais informatizados**. Rio de Janeiro, RJ: 2AB, 2000. 117 p.
- MORAES, Helton Scheer de. **Projeto conceitual de sistemas de assento para cadeira de rodas: uma abordagem sistemática**. 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.

MORAES, Anamaria de; MONT'ALVÃO, Cláudia. **Ergonomia: conceitos e aplicações**. 4. ed., rev. atual. e ampl. Teresópolis, RJ: 2AB, 2010. 223 p.

PRODANOV, Cleber Cristiano; FREITAS, Ernani Cesar de. **Metodologia do trabalho científico: métodos e técnicas da pesquisa e do trabalho acadêmico**. 2. ed. Novo Hamburgo, RS: Feevale, 2013. 276 p.

SOUZA, Dilmara Veríssimo de; ZIONI, Fabiola. **Novas perspectivas de análise em investigações sobre meio ambiente: a teoria das representações sociais e a técnica qualitativa da triangulação de dados**. Saúde e Sociedade, v.12, n.2, p.76-85, jul-dez 2003.

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

VERGARA, M.; PAGE, Á. **Relationship between confort and back posture and mobility in sitting- posture**. Applied Ergonomics, v. 33, n. 1, p. 1-8, 2002.

VÍCTORA, C.G.; KNAUTH, D. R.; HASSEN, M. **Pesquisa qualitativa em saúde: uma introdução ao tema**. Porto Alegre: Tomo, 2000.