Analysis of the ergonomic impact of dental chairs on dental professionals through the application of Survey and Nielsen heuristics

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ABSTRACT

The present study aimed to evaluate the issues involving the ergonomic risks to which dental professionals are exposed, considering that many dental professionals resort to physical therapy treatments in order to treat the recurrent pain of uncomfortable postures that are necessary to perform procedures during the work period. Based on this, an analysis was elaborated focusing on the ergonomics of the dental chair product, taking into account musculoskeletal pain cited by professionals in the area. The ergonomic analysis techniques used were the Nordic Questionnaire, the Borg Scale and the Nielsen Heuristics. The analysis of data from the Nordic Questionnaire and the Borg Scale showed that where pain most often occurs in dentists is in the neck, shoulders and lumbar spine. During the Nielsen Heuristics, points of usability improvement were also identified. At the end of the research, improvements were proposed for future models of dental chairs, and it was concluded that dentistry has a wide field of action for ergonomist professionals.

Keywords: Dental Chair, Occupational Diseases, Product Ergonomics, Borg Scale, Nielsen Heuristics, Nordic Questionnaire.

1 INTRODUCTION

The relationship between human beings and the performance of work causes wear and tear to man, whether cognitively or physically. Ergonomics is the study of the relationships between man and machine that aims to improve safety and efficiency so that both interact in the best possible way. Musculoskeletal disorders and stress injuries are associated with the wear and tear of performing the work, the repetition of movements and the muscular demand of professionals.

According to Graça *et al*[1] (2006, apud NANTES, 2016, p.2), the prevalence of musculoskeletal pain reaches 62% of the population, but in dentists this percentage reaches the mark of 93%. According to Filho and Ribeiro (2007, p.14), dentistry was considered the second most stressful occupation by studies conducted in the United States in the 1990s.

[1] GRACE, D.C.; ARAÚJO, T. M.; SILVA, C. E. P. Factors associated with the prevalence of self-reported musculoskeletal pain in dentists. Rev ABO Nac. 14, 4, 225-31, 2006.

Dental professionals are exposed to a group of occupational risks, including ergonomic risk, often evidenced by incorrect posture, repetitive actions and excessive pace of professionals (LESSA *et al*, 2010). In addition, dentists' work activities often require the professional to remain in uncomfortable positions while performing procedures on the patient. Therefore, there is a need to study and propose improvements in the current way dentists work, seeking to improve the quality of life of professionals in the area, thus preventing the exercise of their profession from affecting their health.

In the present study, we seek to make an analysis of the dental chair, trying to understand how it dictates the dentist's work posture, and therefore his comfort and health, as well as to propose possible improvements to be implemented in the next models. For this study, the SLD Dabi Atlante chair will be analyzed.

2 MATERIALS AND METHODS

Ergonomic analysis techniques can be direct – recording activities for a long period of time on video, processing the data later, observation, or indirect – applying open or closed questionnaires, interviews, check-lists, evaluation tables. The techniques aim to identify ergonomic problems in the execution of the work, thus seeking to contribute to the health and comfort of the worker.

2.1 NORDIC QUIZ

Segundo Kuorinka *et al*[2] (1987, apud Leão, 2013, p.11), the Standardised Nordic Questionnaire for the Analysis of Musculoskeletal Symptoms (NSQ) was developed with the purpose of measuring the most frequent musculoskeletal symptoms in the occupational system.

The NSQ can be assessed in three different ways: a general form (comprising all areas of the body), the other two correspond to specific assessments for the lower back and neck and shoulders. This technique consists of a diagram of the human body divided into nine parts, in which the subject chooses between "yes" or "no" alternatives based on the occurrence of symptoms in the anatomical areas presented (BORMIO et al 2011, p.58). Also according to Bormio et al (op. cit, p.58), "the respondent should report the occurrence of symptoms considering the twelve months and seven days prior to the interview, as well as report the occurrence of absence from routine activities in the last year".

[2] KUORINKA, B. Jonsson; KILBOM, A.; VINTERBERG, H.; BIERING-SORENSEN, F.; ANDERSSON, G.; JORGENSEN, K. Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms, Applied Ergonomics 1987, 18.3,233-237.

Figure 1: Questionnaire for the survey of musculoskeletal problems. Source: Lida, Itiro, Ergonomics and Design and Production. (2018, p.88).

Questionário nórdico dos sintomas de problemas osteomusculares.

Marque um (x) na resposta apropriada. Marque apenas um (x) para cada questão.
Não indica conforto, saúde — **Sim** indica incômodos, desconfortos, dores nessa parte do corpo.

ATENÇÃO: O desenho ao lado representa apenas uma posição aproximada das partes do corpo. Assinale a parte que mais se aproxima do seu problema

Partes do corpo com problemas	Você teve algum problema nos últimos 7 dias?	Você teve algum problema nos últimos 12 meses?	Você teve que deixar de trabalhar algum dia nos últimos 12 meses devido ao problema?
1 - Pescoço	1 ☐ Não 2 ☐ Sim	1 ☐ Não 2 ☐ Sim	1 ☐ Não 2 ☐ Sim
2 - Ombros	1 ☐ Não 2 ☐ Sim – ombro direito 3 ☐ Sim – ombro esquerdo 4 ☐ Sim – os dois ombros	1 ☐ Não 2 ☐ Sim – ombro direito 3 ☐ Sim – ombro esquerdo 4 ☐ Sim – os dois ombros	1 ☐ Não 2 ☐ Sim
3 - Cotovelos	1 ☐ Não 2 ☐ Sim – cotovelo direito 3 ☐ Sim – cotovelo esquerdo 4 ☐ Sim – os dois cotovelos	1 ☐ Não 2 ☐ Sim – cotovelo direito 3 ☐ Sim – cotovelo esquerdo 4 ☐ Sim – os dois cotovelos	1 ☐ Não 2 ☐ Sim
4 - Punhos e mãos	1 ☐ Não 2 ☐ Sim – punho/mão direita 3 ☐ Sim – punho/mão esquerda 4 ☐ Sim – os dois punhos/mão	1 ☐ Não 2 ☐ Sim – punho/mão direita 3 ☐ Sim – punho/mão esquerda 4 ☐ Sim – os dois punhos/mão	
5 - Coluna dorsal	1 ☐ Não 2 ☐ Sim	1 ☐ Não 2 ☐ Sim	1 ☐ Não 2 ☐ Sim
6 - Coluna lombar	1 ☐ Não 2 ☐ Sim	1 ☐ Não 2 ☐ Sim	1 ☐ Não 2 ☐ Sim
7 - Quadril ou coxas	1 ☐ Não 2 ☐ Sim	1 ☐ Não 2 ☐ Sim	1 ☐ Não 2 ☐ Sim
8 - Joelhos	1 ☐ Não 2 ☐ Sim	1 ☐ Não 2 ☐ Sim	1 ☐ Não 2 ☐ Sim
9 - Tornozelo ou pés	1 ☐ Não 2 ☐ Sim	1 ☐ Não 2 ☐ Sim	1 ☐ Não 2 ☐ Sim

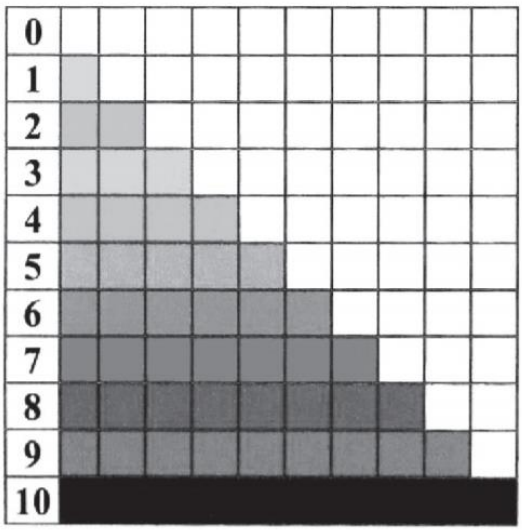
2.2 BORG SCALE

The Borg Scale was developed by Gunnar Borg, a Swedish physiologist, in 1970 with the aim of classifying the subjective perception of exertion. In this sense, the Borg Scale is used so that the evaluated worker indicates his/her perception of effort or discomfort in relation to his/her activities (LIDA, 2018, p.86).

The technique forms a table with intensities ranging from 0 to 10, as shown in the figure below:

Table 1. Borg scale. Source: KELEN, C.; UNIPE, C.; BRASIL, F. C. M. P. B, Ergonomic assessment of rural workers: focus on occupational risks associated with physical workload. (2011, p.104).

ESCALA DE BORG
Legenda
0 - absolutamente sem dor
1- discreta dor
2 - apenas perceptível
3 - dor muito perceptível
4 - dor levíssima
5 - dor leve
6 - dor quase intensa
7 - dor intensa
8 - dor pouco suportável
9 - dor quase insuportável
10 - dor máxima



2.3 NIELSEN HEURISTICS

Nielsen heuristics were developed in 1990 by Jakob Nielsen and Rolf Molich and published in the paper "Improving a human-computer dialogue, Communications of the ACM 33". In 1994 Jakob Nielsen refined the previously published heuristics based on a factor analysis of 249 usability problems, resulting in a set of heuristics with the greatest possible explanatory power. This set of revised heuristics remains unchanged to this day (NIELSEN, 2020). "When something holds true for 26 years, it's likely to apply to future generations of user interfaces as well" (NIELSEN, 2020).

Nielsen's 10 heuristics are: System status visibility; Compatibility between the system and the real world; Control and freedom for the user; Consistency and standardization; Error prevention; Recognition rather than memorization; Efficiency and flexibility of use; Minimalist aesthetics and design; Help users recognize, diagnose, and recover from errors; Help and documentation.

Figure 2: 10 usability heuristics.

Fonte: Nielsen, J. (1994b). Heuristic evaluation. In Nielsen, J., and Mack, R.L. (Eds.), Usability Inspection Methods, John Wiley & Sons, New York, NY.

2.4 APPLICATION OF ERGONOMIC ANALYSIS TECHNIQUES

To perform the Nordic Questionnaire, answers were collected from a sample of dental professionals who, as described in the context of the QNSO, will answer "yes" or "no" to report musculoskeletal pain and symptoms in the last 12 months.

The application of the Borg Scale was based on the method used in the article "Ergonomic assessment of rural workers: focus on occupational risks associated with physical workload" (2011), which consists of asking workers to rate the level of their pain, based on the scale, after the work period.

In addition, we analyzed how Nielsen's heuristics are already applied in the dental chair of the SLD Dabi Atlante model, and how they can contribute to possible usability improvements in future models. It is

important to note that Nielsen heuristics were created for digital interfaces, so not all of them will have application in an analog object such as a dental chair. "Heuristics are 10 general principles for design. They are called 'heuristics' because they are ground rules rather than specific usability guidelines" (NIELSEN, 2020).

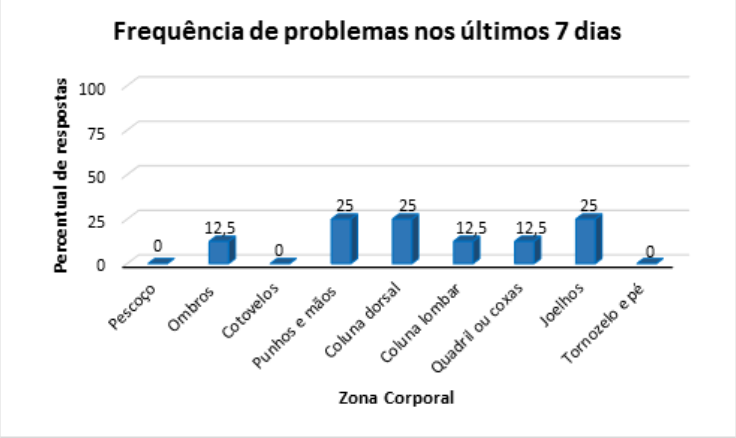
3 RESULTS AND CONCLUSIONS

3.1 NORDIC QUESTIONNAIRE RESULTS

The Nordic Questionnaire was carried out following an analysis carried out with eight dental professionals, allowing a simplified assessment of musculoskeletal pain. To validate these data, a Google form was applied, divided into ten sections containing the information to be analyzed. Initially, the survey pointed out that 100% of the interviewees are right-handed, with five people who made up the sample female and three male. From there, the research was carried out following the same pattern foreveryone.

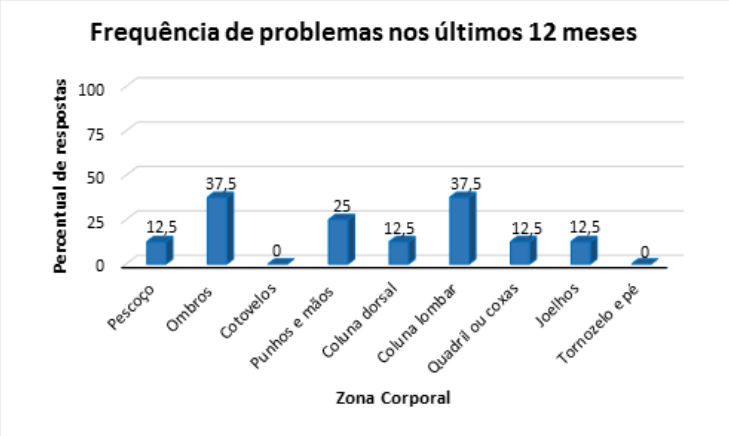
For the analysis of the frequency of problems in the last 7 days, a small difference was noticed in which the results range from 0% to 25%, as can be seen in graph 1. The highest incidence of musculoskeletal symptoms was also in the region of the wrists, hands and fingers, followed by the dorsal spine and knees. There were no reports of pain in the neck, elbows or ankles, and foot.

GRAPH 1. Search results - Pain in the last 7 days.



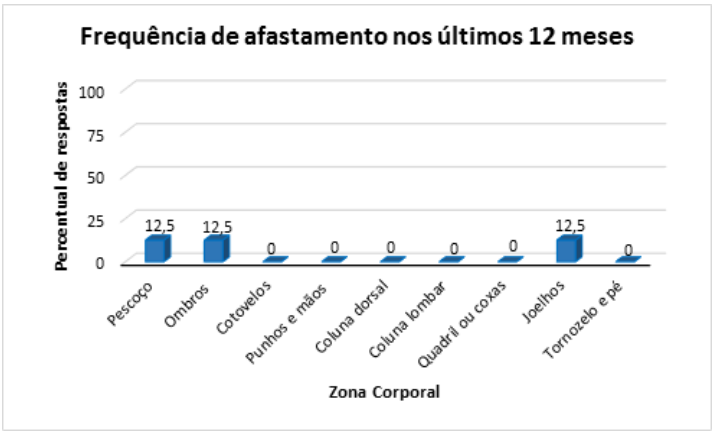
For the analysis of the frequency of problems in the last 12 years, a small difference was observed, in which the results range from 0% to 37.5%, as can be seen in graph 2. The highest incidence of musculoskeletal symptoms was in the shoulder region, followed by the lumbar spine.

GRAPH 2. Search Results - Aches and pains in the last 12 months.



For the analysis of the frequency of sick leave due to a musculoskeletal problem in the last 12 years, the results ranged from 0% to 12.5%, as can be seen in Graph 3. The biggest complaint was pain in the neck, shoulders and knees.

GRAPH 3. Search results - Leaves.



Finally, it was reported in this study as an observation by the interviewees that the practice of physical exercises together with body therapies help in the prevention and treatment of musculoskeletal pain.

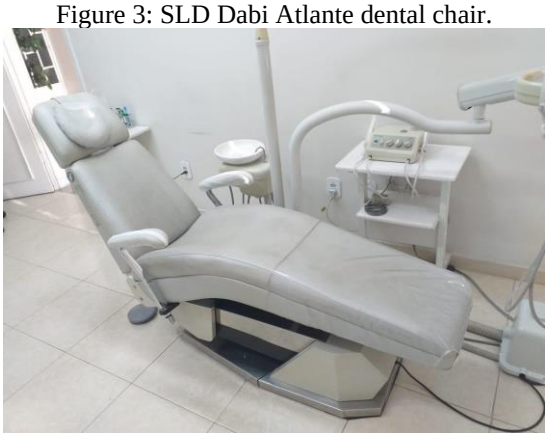
3.2 RESULTS OF THE BORG SCALE

After a period of one working day, one of the dentists who participated in the Nordic Questionnaire was asked to report, based on the Borg Scale (Table 1), his level of pain and the location. The professional in question is 60 years old and does not have any physical disability. The reported pain was level 3 (very noticeable) in the neck and level 1 (mild pain) in the lumbar spine region.

3.3 RESULTS OF NIELSEN HEURISTICS

The SLD Dabi Atlante dental chair offers control buttons that serve to move the chair vertically, change the backrest tilt and return to the default position.

Figure 3: SLD Dabi Atlante dental chair.



1st Heuristic: The visibility of the system's status, which is focused on the user's feedback in relation to the actions he takes, is well applied, as it offers visual and audible signaling when the chair is performing any of the movements triggered by commands.

2nd Heuristic: The correspondence between the system and the real world does not apply in this case, because it is an analog object.

3rd Heuristic: Regarding the control and freedom of the user, the chair works well, as it allows different movements, allowing the user to control freely as far as its articulation allows. As it moves slowly, if the user presses any wrong button, the progress of the position to which he is making the adjustment is not greatly compromised. In addition to the movements of the chair, the headrest has its own movements, and can be better adjusted to the patient and the position he needs to be.

Figure 4: Representation of the maximum slope.

4th Heuristic: The consistency and patterns heuristic does not apply, as there are no symbols or words inscribed on the chair.

5th Heuristic: The error prevention heuristic is very well applied, because the chair allows great freedom of movement, but limits how far these movements can go. This ensures that the user does not damage the chair, injure the patient, or drop them. At the base of the chair is a button that acts as a foot pedal for emergency stop.

Figure 5: Emergency button.

6th Heuristic: The heuristic of recognition instead of memory was not well applied, because the buttons do not have any identification of the functions, forcing the user to memorize the actions performed by each one of them.

Figure 6: Dental Chair Control Knobs

7th Heuristic: The heuristic of flexibility and efficiency of use does not apply, as there is no type of customization of the use of the buttons by the user, such as moving faster for the already experienced professional, for example.

8th Heuristic: The aesthetics and minimalist design heuristic does not apply because there is no interface, so there is no visual element that causes unnecessary distraction.

9th Heuristic: No ways of applying the recovery heuristic in the face of errors were identified.

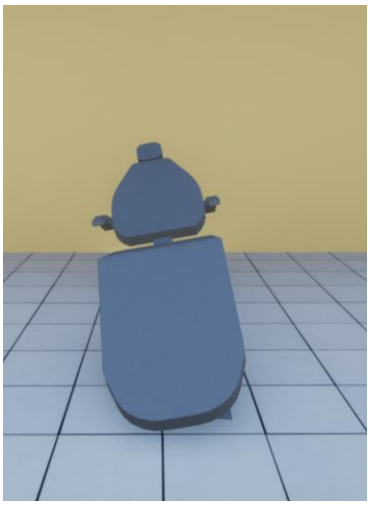
10th Heuristic: Regarding help and documentation, the chair has a small instruction manual, which is therefore unsafe, because a dental professional uses the same dental chair for many years, which can lead to the loss of the manual. This loss occurred with the professional who owned the chair used for the heuristic analysis.

3.4 COMPLETION OF RESULTS AND PROPOSAL FOR IMPROVEMENTS

After the application of the Nordic Questionnaire and the Borg scale, it was concluded that the regions where pain most frequently occurs in dental professionals are the neck, shoulders and lumbar spine, so these are the areas that should receive more attention in future changes in the dental work environment. Saliba, Machado and Garbin (2021, p.97) confirm this by stating that "[...] there is a high prevalence of disorders related to the practice of the profession among dental professionals, especially back and neck pain".

A proposal for change focused on the dental chair that can reduce these pains is to have chair rotation movement commands, so that the patient is a few degrees turned towards the dentist, thus making the professional bend the body less towards the patient. It is important that this swivel is calculated in such a way that the patient is not in danger of falling, perhaps for this purpose by increasing the side protection of the chair.

Figure 7: Representation made in software. Dental chair with 10° swivel.



After the application of Nielsen heuristics, points of improvement were seen in future models of dental chairs. A clear and easy-to-perform improvement is based on the 6th Heuristic, where the chair's control buttons should present images that illustrate its actions, thus avoiding the need for the user to memorize.

Another possible improvement identified during the analysis is based on the 10th Heuristic, in which the professional who owns the chair should always be able to access the instruction manual. Seeking to avoid the physical manual as the only means of information (after all, this can be lost), it is recommended to insert a QR Code, or other tool of the kind, in a discreet point of the chair, which when scanned leads to an online instruction manual.

3.5 OVERALL CONCLUSION

In addition to the various ergonomic and mechanical risks in the dentist's profession, some of which are addressed in the present study, Lopez and Lessa (2010, p.6) point out that such professionals are also exposed to physical, chemical, and especially biological risks. This finding demonstrates how ergonomics and occupational safety engineering can play a role in dentistry to make the practice of this profession safer and healthier. After all, according to Saliba, Machado and Garbin (2021, p.97), "there are still few studies on ergonomics applied to Dentistry [...]".

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