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The influence of applied pressure on the seated person and the prediction of early discomfort – protocol for a systematic review

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Abstract

Sitting comfortably in a vehicle, office or at home, besides design characteristics, requires excellent physical support of the material to the exposed body segments. An uncomfortable seat can cause well-known pain such as lower back pain, which is nowadays become as "chronical" pain among all the seated workers. This systematic review protocol is based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols (PRISMA-P) Statement and presents a methodology to find possible evidence of critical values of the applied pressure which can cause negative impact on the soft tissues of the seated person. Furthermore, if it is possible to correlate obtained critical values with the time spent in the sitting position. Based on this, the main databases (Scopus, PubMed and Science Direct) will be searched using the same keywords combination for all of them. Afterward, articles selection process, data extraction, and validation will be approved independently by the reviewers and collected data will be summarized in a spreadsheet table. Outcomes of the selected articles will be examined in the details and will be analyzed in order to extract the main results.

1. INTRODUCTION

1.1. Background

From the design of basic chairs for common use to the design of a seat for the automotive industry, comfort has been considered as the most critical factor (Ebe et al., 2010). However, the design requires the application of different standards to create a comfortable seat for each kind of use. In situations of static comfort (where there are no external factors such as vibration caused by the engine, for instance) the design of the seat does not need to meet the same requirements as another seat submitted to dynamic situations of use.

Individual characteristics (age, weight, gender, among others) and person posture habits can present different pressure distributions (Ebe et al., 2010). Furthermore, a seat needs to guarantee some features such as seat hardness, seat shape and anatomical characteristic of a person to satisfy comfort (total contact area, pressure values at the specific points, the total maximum pressure during the exposure and peak, an average of the pressure). Prolonged sitting, from the ergonomic point of view, in the automotive industry, needs to consider head and other body parts support (foam with a suitable size and density) otherwise it can introduce the high applied pressure in a certain zone of the seat (Andreoni et al., 2002; Mergl et al., 2010).

When the driver is seated and steering the vehicle, his body weight is supported by the seat in more than 70% of his total weight, and his body posture can cause higher pressure in the ischial tuberosity (H. C. Lee et al., 2007; Kolich, 2004). Depending on the seat comfort/discomfort, the pressure can hamper blood circulation, causing pain in the lower back, as well as in the remaining parts of the lower limbs, causing deformation of the different layers of the soft tissues (Jackson et al., 2009; Al-Dirini et al., 2015). As the main consequence, the amount of oxygen in the tissue decreases (Olesen et al., 2010) generating discomfort (Al-Dirini et al., 2015; Vink et al., 2012). Taking into consideration the posture taken by the drivers and the physical characteristics of the seat, all these factors need to be carefully exanimated to make the drivers' seat a comfortable place (Ebe et al., 2010).

Establishing a correlation between the interface pressure and seat comfort, Kamijo et al. (1982) demonstrated an assessment method with a passenger car seat under static conditions. In the evaluation of the car seats, the measured characteristics were the static pressure distribution, static deflection, and vibration. It was concluded that the driving posture changes and its pressure distribution had a big influence on the static comfort evaluation. Based on seat characteristics previously established by Kamijo et alc J. Lee et al. (1993) developed their work, adding a few more seat exact parameters, such as foam thickness and hardness, angles of the back support and cushion, and side support. Due to a large number of subjects, the authors could not find enough data to link the pressure distribution and comfort regarding design decisions. Gross et al. (1994) lead an experiment whose goal was to link the perceived comfort of 12 aspects of the seat. As a conclusion, it was perceived that comfort was highly related to pressure data statistics in the short-settled time. However, discomfort could not be deduced after this short experimental time, as well as the conclusions that came from it.

Some authors states that the comfort is not only related to the seat design (including all physical characteristics) (Porter et al., 1998), but also from non-ergonomic body posture of a seated person (Helander et al., 1996; Helander et al., 1997, Oudenhuijzen et al., 2010). Most of the studies represent the overall pressure, not considering that the different parts of the lower limbs have different capacity to handle different value of pressure (Gross et al., 1994; Kamijo et al., 1982; Porter et al., 1998).

Dividing area of the applied pressure into segments such as the front thigh, mid-thigh and buttocks can introduce thresholds and provide a better understanding of the problem (Hartung, 2006; Mergl et al., 2010). Mergel (2010) suggest that the contact area of the load needs to be from 50 until 65% (with the maximum pressure gradient of 5.6 kPa/mm) handled with the buttocks, 14% (with the 1.6 kPa/mm) by mid-thigh and less than 6% (0.5 kPa/mm) supported by the front of the thigh. The proposed values were established on the subjective evaluations of the participants and need to be compared with the objective evaluations.

1.2. Objectives

The main goal of this work is to design a protocol in order to perform a systematic review to establish the connection between pressure distribution, comfort/discomfort and possible musculoskeletal disorders of the driver. What is more, for the better definition of the general objective, specific objectives are raised by the following questions:

- What are the common values of the pressure distribution applied to the seat by the driver?
- Is it possible to evaluate (dis)comfort with the pressure values applied by the driver on the seat?
- What is the relationship between prolonged sitting, applied pressure and fatigue?
- Can a different type of seat cause different values of (dis)comfort and applied pressure?
- Is it possible to establish a relationship between seat type and applied pressure to establish the level of (dis)comfort?
- Can increase seat pressure cause posture changes over time?

2. METHODS

2.1. Research framework

This Systematic Review protocol is based on established guidelines in the Preferred Reporting Items for Systematic Reviews and Meta-Analysis Protocols (PRISMA – P) Statement (Moher et al., 2016).

2.2. Eligibility criteria

Type of studies

In this systematic review will be considered:

- Published articles, or articles in the press, on the topic of applied pressure on the seat;
- Articles that provide reliable information about the pressure characteristics and exposure time;
- Articles that define methods for (dis)comfort assessment;
- Articles that clarify equipment characteristics and the calibration;
- Articles that assess the impact on (healthy) adult participants;
- Articles which do not include mat surface pressure mapping technology but does include another technique to measure applied pressure on a seat and provide possible musculoskeletal disorders.

In addition to the previous inclusion criteria, special attention is going to be paid to studies providing pressure distribution on the lower limbs, which also present zones/areas (considering negative impact or possible musculoskeletal disorders on the mention body parts). Articles analyzing applied pressure on the drivers' seat will also be considered.

Will be excluded:

- Non-research articles, such as opinion articles, reports, conference abstracts and papers;
- Studies which provide information on applied pressure on the seat, using a mechanical or simulation model research.

The inclusion or exclusion of another kind of articles will be explicitly reported and justified in the systematic review.

Type of participants

The research does not require specific participant characteristics, such as gender or age, once it is focused on general (healthy) population. Further restrictions will not be considered since the study is focused on the (negative) impact of pressure distribution on the human body.

Report characteristics

Based on the current development in technology, the research will be established, at least, in two phases. The first one settles articles published in the period between 2013 and 2018. The search of the literature will be done considering only publications written in English and published in journals. The references from the collected articles will be screened and will include, in the second phase, articles published before 2013. In regard to obtaining more relevant outcomes on the current results and understanding the pressure (negative) impact on the musculoskeletal disorders, thesis and dissertations will be involved as well. The process will be repeated until no more relevant results are obtained (Wohlin, 2014).

2.3. Information sources

The systematic review will include the following electronic databases: SCOPUS, Web of Science, Science Direct, Pub Med, Inspec, Springer and Science Magazine. Furthermore, scientific journal databases will be screened: Directory of Open Access Journal (DOAJ), Emerald, IEEE Explore, Ingenta, ACS Journal, and Taylor and Francis.

2.4. Search strategy

Refereeing to the aim of the study, the research strategy relies on defined keywords, which are divided into four groups. The first group is the main one and will be combined with the rest of the sets. The terms in the first group are "interference pressure", "pressure distribution", "pressure measurements" and "contact pressure". The following group contains the keywords: "sitting posture", "fatigue" and "comfort". The set keywords for the third and fourth group are, "comfort model" and "standards" (for the third group) and "seat" (in the fourth). Additionally, some keywords were combined between the other groups.

A complete list of the combination will be following:

"interface pressure" AND "sitting posture"; "interface pressure" AND "comfort model"; "interface

pressure" AND standard; "interface pressure" AND seat; "pressure distribution" AND "sitting posture"; "pressure distribution" AND "comfort model"; "pressure distribution" AND standard; "pressure distribution" AND seat; "pressure measurement" AND "sitting posture"; "pressure measurement" AND "comfort model"; "pressure measurement" AND standard; "pressure measurement" AND seat; "contact pressure" AND "sitting posture"; "contact pressure" AND standard; "contact pressure" AND seat; "sitting posture" AND "comfort model"; "sitting posture" AND standard; "sitting posture" AND fatigue; "sitting posture" AND comfort.

The search will be done in the title, abstract an keywords of the articles. Additional terms can be added after achieving the objective of the systematic review. The new keywords, from the second phase of the search, will be added to the previously defined keywords and new research is going to be carried out.

What is more, selected articles will be analyzed through text and the references (articles published before 2013, as previously stated). The algorithm of a defined search strategy will be repeated as long as all the needed information are obtained.

2.5. Study records

Data management

After finishing the research process, the selected records will be imported and managed by Mendeley software for the de-duplication stage. If is not possible to automatically export all the selected articles, the alternative will be manually collecting all the needed information into a Microsoft Excel file sheet. This process requires the analysis of the title and abstract of each article. Taking into consideration the previously established inclusion criteria, the full-text will be assessed and examined in detail. With the purpose of tracking the selected articles, all the information will be inserted in a table (see Annex 1).

Selection process

The selection process relies on inclusion/exclusion criteria and, as such, the criteria need to be clearly defined and implement in three phases.

The first stage is established based on the previously defined criteria (*2.2 Eligibility criteria*). This phase will be implemented separately by two researchers, and the selected articles will be combined in a specially designed table. Afterwards, a separated revision will be performed by another two authors. At this point, if any of the reviewers are not satisfied with the selected articles, can require additional inclusion/exclusion criteria, or, if appropriate, add new keywords to the research. If the authors are satisfied with the results, the final step will be combining the selected articles in one file presented through a table. If there are any disagreements between any of the authors, the final decision will be on the first author.

Data collection process

After selecting the articles, all the extracted information will be placed in a specially designed table with the aim of answering the defined research objectives. The first author will analyze the selected articles with all the essential information. Beside general established criteria, more specified criteria will be implemented. Considering study characteristics in the articles, it will be searched for information related to the type of data, used equipment and its calibration, used software, applied methods, anthropometric characteristics, and sample size. Quality assessment will be based on the possible risk of bias (selection, precision and information bias) (Higgins et al., 2011).

2.6. Data items

Defined variables or vital data will be elaborated into two separate sections. First part will include all the relevant data of the volunteers, such as: age, sex, body mass index (kg/m^2), health status, number of participants, difference of the pressure regarding the participant's sex, applied pressure area, peak pressure, average pressure, duration of experiment, and type of the seat. Another division will include, but not be limited to: author, authors' country, equipment, number of sensors, additional equipment, software, pressure unit, study goals, standards (if any), and ethical committee approval of the experiment.

2.7. Outcomes and prioritizing

The general result defined for this study is the critical value of applied pressure and its negative impact on the human body. Furthermore, specific outcomes are the following:

- To define the (negative) consequences caused by applied pressure on the seated person
- To recognize if the posture can cause pressure changes in the seat pan
- To correlate the pressure distribution with a total cover area
- To link peak, average and critical values of the pressure

2.8. Risk of bias in individual studies

Bearing in mind both specific and general study objectives, risk of bias (Higgins et al., 2011) will be applied at the study level considering all parameters (study objectives, variables, used equipment, applied methodology, defined time of the experiment and assessed procedures) and general characteristics (data sources, used standards, assessment tools in accordance with specific goals of the systematic review).

Defined groups (parameters and general study characteristics) will be determined and, lately, divided (for the article's analysis) into groups. Cochrane Collaboration's Tool (Higgins et al., 2011) will be used as a reference for the determinate risk of bias for each article. The range of the topics will be defined as "high", "low" and "unclear" (where "unclear" demonstrates non-defined or missing information, in order to accomplish the information in need).

2.9. Data synthesis

The data synthesis will be following the checklist of Preferred Reporting Items for Systematic reviews and Meta-Analysis (PRISMA) Statement (Moher et al., 2009). Due to the final outcomes, a meta-analysis was not planned. The final extracted data will be presented in table-form and will be carried through a narrative synthesis. Commenting on the risk of bias and describing the included studies and its results will be presented in the first phase. The following stage will be systematically assessing the results of each selected study, highlighting the outcomes and relating with every included article.

2.10. Meta-bias

This parameter does not apply to the study which will be carried out.

2.11. Confidence in cumulative evidence

This parameter is not applicable to the proposed systematic review.

2.12. Protocol registration

The protocol is under revision by PROSPERO.

2.13. AUTHORS' CONTRIBUTION

Study design and development: MC, JD, JSB, DS

Title and abstract screening: MC, JD

Full-text screening: MC, JD

Data extraction: MC, JD, JSB, DS

Critical appraisal: MC, JD, JSB, DS

Data analysis and interpretation: MC, JD, JSB, DS

Draft of the protocol: MC

Support in draft's development: MC, JD, JSB, DS

All authors read and approved the final version.

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Annex 1

Table 1 - Form sheet summarizing the rejection criteria which will be used to conduct the systematic review

Data base / Journal	Keyword 1 x Keyword 2							
	Number of Selected Articles	Number of Collected Articles	Number of included articles after criteria insertion					
			Date	Document type	Source type	Language	Off topic	Other
IEEE Xplore								
Inspec								
Science Direct								
Taylor and Francis								
ASC								
DOAJ								
Emerald								
Ingenta								
Scopus								
Springer								
Web of Science								
PubMed								
Science Magazine								