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Examples of the application of the cause-effect ergonomic evaluation model to the wheelchair cushions

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Abstract. This article highlights the potential of the application of the cause-effect model for the ergonomic evaluation in the field of cushions. User involvement in the prescription and development of assistive devices have been identified a key aspect for positive interventions, although the reality is that we lack of systematic approaches and examples of best practices. The potential benefits are identified for the development of new products and in the prescription process. Additional research would be necessary to better link the characteristics of the cushions and users with the biomechanical and physiological performance of the interface cushion-user and the consequences measured in health, user perception and activity performance. This article shows examples of the relationship in this three levels from the point of view of the user perception.

Keywords. Cause-effect model, cushion, pressure sore prevention, user involvement, prescription and assignment, product development.

1. Introduction

There is a wide correspondence between users of wheelchairs and cushions to prevent pressure sores. Defining people who use cushions is basically the same as defining and characterizing people who use wheelchairs, as most users of wheelchairs and scooters are also cushions users [1]. The cushion as the most common accessory among wheelchair users, employed by 56% of manual wheelchair users and by 71% of powered wheelchair users [2]. These rates of use being high are not universal; although it is likely to have increased in recent years because of a greater awareness.

Among the users of wheelchairs and cushions we can find people with very different needs, such as neurological users (spinal cord injured, multiple sclerosis), users with musculoskeletal problems (scoliosis, fractures ...), users with learning problems or older persons. From a numerical perspective, the percentage of people in wheelchairs (manual or electric scooter), according to various articles of American population and European countries varies between 0.62% and 2%, most data concentrated around 1% [3] This reference value means five million users of wheelchairs in Europe.

Wheelchair users may stay in a seating position for 10 and 16 hour per day [4], enough argument to define objectives for the seating system, where the cushion is integrated. Objectives that may be classified in three basic areas: health, position and

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comfort [5, 6]. From the **health** point of view, the most important seating objective for wheelchair users is the prevention of pressure sores. Traditionally the approach has been to apply mechanisms for pressure redistribution in the contact interface cushion-person. If we consider **position** we need to link it to an activity. A common way to classify these activities is in three categories: active (working on a table or propelling the wheelchair), semi-active (watching TV or casual conversation) and relax (taking a nap). Finally, when focussing on **comfort** we assess the users perception normally linked to the lack of pain.

The importance of the implication of the users in the prescription process, have been highlighted as a key element to ensure the adherence to the use of the products and avoid early dropouts.

To incorporate the user adequately in the evaluation and development of new products implies the need of models for product innovation and development that allow the incorporation of users in a systematic way. That is the utility we can gain

2. The cause-effect model applied to the cushions

The cause-effect model was originally defined in the field of ergonomic evaluation. "The aim of any ergonomic assessment methodology is to stablish in which aspects the furniture [cushion] designed is adequate or not to the characteristics and needs of the users, producing specific data useful to offer feedback to the designer or manufacturer in order to improve the product. That implies to test the furniture [cushion] in similar conditions to the real use, and by subjects representing accurately the potential users and to obtain quantifiable information about subjective comfort sensations and other objectives parameters determining them" [7]. Figure 1 shows the cause-effect model based on three levels of evaluation, adapted to the cushions.

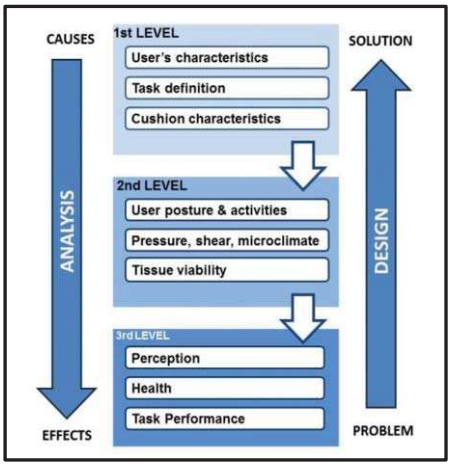

Figure 1. Cause-effect model adapted to the cushions

This model of evaluation has been successfully used in different fields such as furniture, footwear or car industry [7, 8, 9, 10]. In the adapted version to the cushions, the **first level** will include the characteristics of the cushion (shape, dimensions, materials, adjustments, etc.), of the user (body dimensions, age, sex, disability …) and the activities to be performed (preventive movements, general active task, semi-actives

task or relax). This group of characteristics determines the factors of the **second level**, relative to the direct body's response of the subject in a configuration of the cushion and the performance of a specific task. Finally, the **third level** groups the consequence of the body's response has on comfort (pain and discomfort), health (pressure sore development), and overall assessment of the product and the performance of the activity.

The application of this model has several potential benefits. For example to help the designers to find the relevant information that can be translated into design rules for better adapted cushion or to help the prescribers to better match the characteristics of the cushion to the user needs.

3. Examples of matching the characteristics of the cushion with the performance of the interface and the perception of the users

The relations stablished in this point are based on the assessment of 24 different cushions organized in seven categories by 34 wheelchair users. The typologies of cushions used where the following: water-gel, air, silicone coated fibers, foam-latex, wool, foam-viscous fluid and foam-gel.

The characterization of the cushion was performed following ISO 16840-2:2007 for first level variables and IBV own procedures for measurements of the interaction and perception values.

3.1. Relationships between level 1 and level 2

Examples of the relationships identified are the following:

- The thickness of the cushion reduces the dispersion index value (0,252**), being the dispersion index the percentage of pressure allocated in the isquial area in relation to the entire contact surface.
- The thickness of the cushion reduces the maximum pressure in the interface (0,164**), calculated the maximum pressure as the mean value of the 10% of the sensors recording the maximum pressure values.

3.2. Relationships between level 2 and level 3

The contact surface and the dispersion index are related to the dampened and sinking feel, in such a way that sinking and dampening behave in opposite directions. When surface increases higher is the feeling of damping (0,148*) and lower is the feeling of sinking (0,210**). On the contrary when higher is the distribution index lower is the feeling of sinking (0,162*) and higher is the feeling of damping (0,226**).

3.3. Relationships between level 1 and level 3

Examples of the relationships identified are the following:

- The firmness feel depends on the cushion typology and normal and overload depth contour values. Higher values of normal and overload contour values give lower perceptions of firmness.

- Balance feel depends on the risk values according to Braden scale for the users and the typology of the cushions. Higher risk values were related with higher balance perception. The cushions with higher balance perceptions were air, water-gel, and foam-latex.

4. Conclusions

The potentiality of an approach of evaluation based on a cause-effect model in the field of cushion has been demonstrated. Additional research should be perform to better match the characteristics of the cushions and wheelchair users to the desired results of the behavior in the interface cushion-person and the corresponding consequences measured in comfort/perception, health and task performance.

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