Final Report - Lumbar Support for Drivers
ED3010 - Human Factors in Design

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Abstract

The report outlines the problems faced by drivers due to an inadequate lumbar support in their car seats. A novel design for a lumbar support is suggested and justified to the reader. A CAD model is also presented and explained to the reader for better visualization of the concept.

1 Introduction

Lower back pain is one of the most prominent cause of physical disabilities. It can be categorized into two types namely acute and chronic. Acute lower back pains are generally transient and lead to only physical pain and trauma in the short period, whereas chronic back pains have a strong psychological effect in addition to physical impacts like work dissatisfaction, boredom, laziness etc.[1]

According to various studies and surveys, 60% - 80% of the populace suffers from or has suffered from lower back pain at some point in their lives.[2] In a study,[3] Kelsey JL and Hardy J determined how driving motor vehicles is a risk factor for acute herniated lumbar invertebral disc. Another study by Walsk K and Vames N reported that the lifetime incidence of lower back pain was 63% amongst the subjects under study. For men, the strongest associations were with heavy lifting and prolonged car driving.[4] Thus lumbar support cushions have been conventionally used to improve the lumbar posture and provide comfort during long commutes. This helps curb lumbar flattening and increases the thoracolumbar curvature of the spine and also reduces the occurrence of short and long term lower back pain.[5]

Many of the conventional lumbar support systems for car seats available are either very rudimentary or are electronically and pneumatically adjustable, complex systems. We aim to solve the problem of providing adequate lumbar support by designing a cheap and effective retrofittable lumbar support mechanism that caters to the need of a wide range of people. While making it simple to use and manufacture, we also want to meticulously design it to accommodate all the vital bio-mechanical factors into consideration.

1.1 Problem Statement

To redesign a retrofittable lumbar support system for automobile seats, that can be adjusted for height and which reduces lower back pain and also aims to correct the posture of the driver. The central concept adhered to while designing the lumbar support system is that it should be solely mechanical, should not involve any electrical components and also be adjustable to suit the needs of drivers of various heights and weights.

1.2 Hypothesis

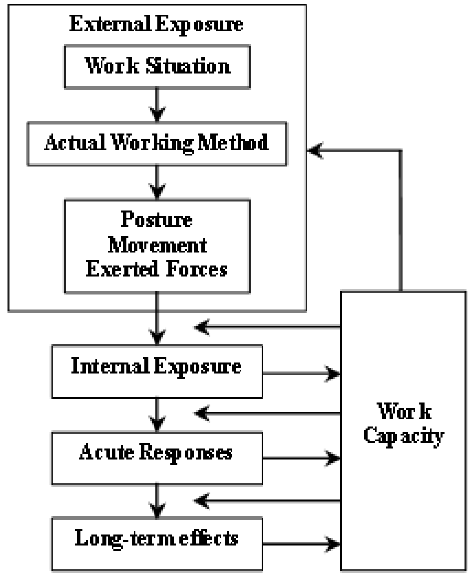
Our conjecture is that the spinal posture for drivers in normal car seats found in low and mid-range priced cars is not favorable and this leads to lumbar disorders in those who drive consistently for long stretches. This can be corrected by using lumbar-support cushions as a supplement in their current car seats.

1.3 Objective

To redesign a modular, height adjustable lumbar support system for passenger car seats, which reduces lower back pain and also corrects the posture of the occupant of the seat. The solution must be compatible with all car seat types and should be suitable for both female and male drivers over a wide range of height.

1.4 Human Factors Problem Targeted

The human factors problem targeted by my team and I is that of *Physical Ergonomics*, which deals with the physical load on the human body.



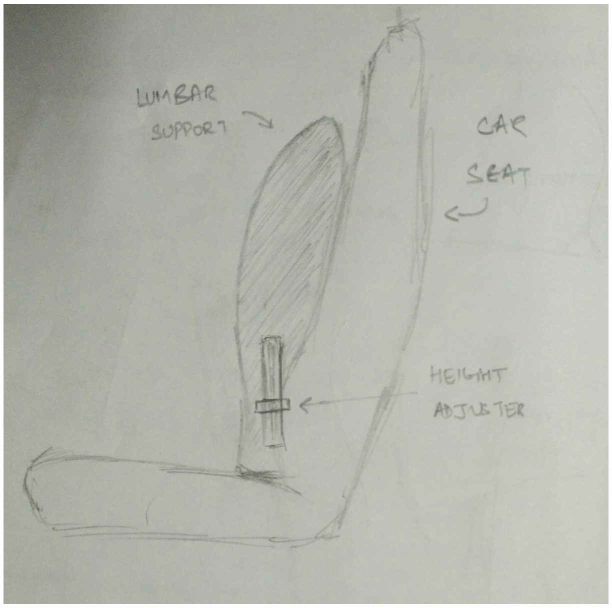
The human at work is (externally) exposed to a work situation (work demands, working environment) and working methods (the work activities to be performed). These result in the adoption of specific human body postures and the execution of movements, as well as some external forces on the human body. Furthermore, the exposure to posture, movement and force leads to the exposure to internal forces on body structures and to elevated levels of energy expenditure (i.e. internal exposure). Mechanical and physiological responses occur in the short term (i.e. acute responses). Musculoskeletal disorders are among the potential longer term effects that follow acute responses. Musculoskeletal disorders are among the potential longer term effects that follow acute responses. The responses and depend also on the individual worker's capacities (including body dimensions, physical fitness, condition).

2 Concept

2.1 Concept 1

The original concept consisted of a large, soft cushion with a stiffer portion inside it that was mounted on a rack and pinion mechanism with the sprockets in the rack unidirectional to enable the movement of the stiff support in the vertical plane in the upward direction, thus it would be able to cater to people of various heights. The adjustment lever was placed on the side of the cushion so as to be easily accessible. It was also spring loaded onto the rack so that it could be pulled and then released to move it in the downward direction.

The outer cushion is shaped so as to correct the posture of the driver to that while standing, as this posture has been found to put the least amount of load on the user's lower lumbar region.



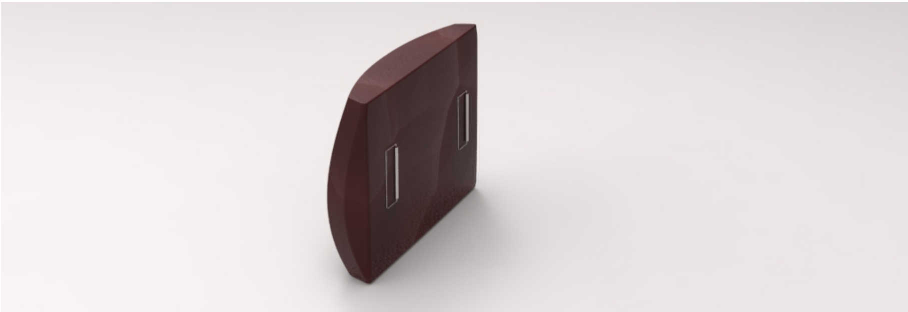
The original concept

2.2 Concept 2

The curvature of the lumbar support cushion is designed to ensure that the lordosis of the spine is as close as possible to that while standing in a relaxed posture. This curvature has been found to be optimal for reducing the stress on the lumbosacral region of the spine.

The cushion also needed to be mounted on a variety of car seats, hence we designed it to be fitted onto a pair of belts running along the surface of the seat with the help of clamps that use torsion springs. This design allows the user to adjust the placement of the support according to his/her height, which enables the support to be used by people of varying heights without compromising on the comfort provided by the cushion.

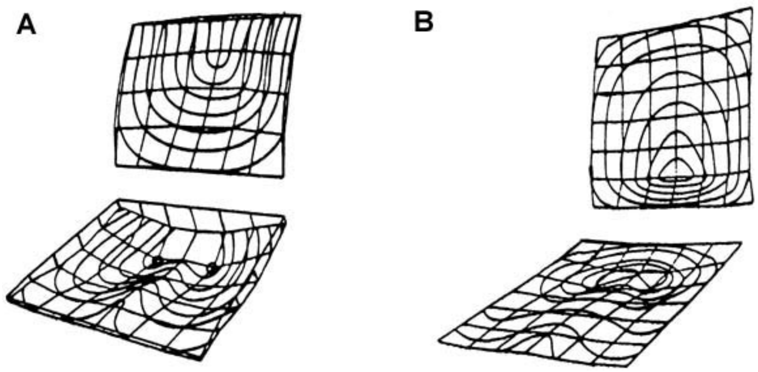
The cushion is to be made of memory foam which will, over time, conform to the shape of the user's spine, thus providing additional comfort to the user that would otherwise be ambiguous in nature.



The final concept

2.3 Proof of Concept

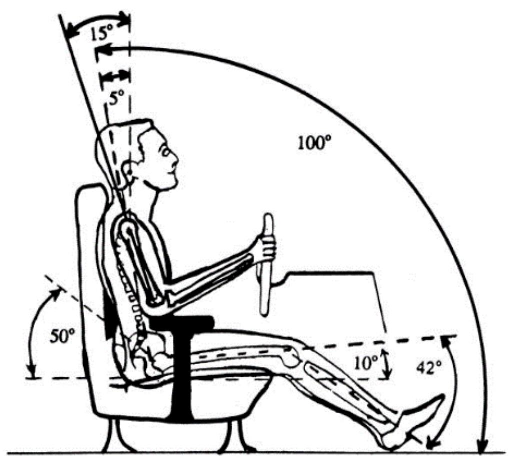
The optimal spinal model for the driver is the average Harrison model,[6] with the seat back angle inclined at 10 degrees in the posterior direction.[7] The seat pressure distribution in a soft seat and that in a firm seat with lumbar support is illustrated below:



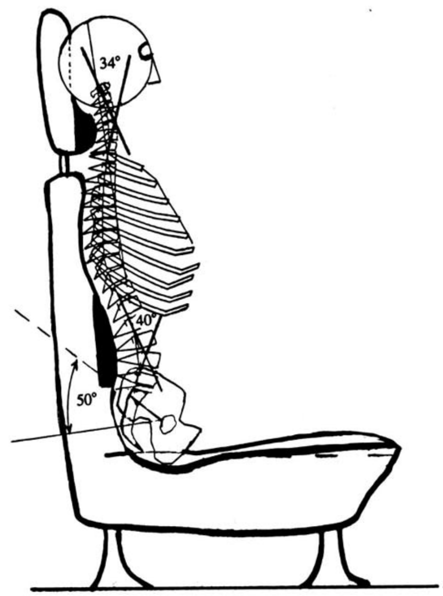
Seat pressure distribution in a soft foam seat without lumbar pad (A) versus a firm foam seat with lumbar back support (B).

From the same study, it was proposed that the optimum driver seat should have the following attributes:

1. The backrest of the seat must have a lumbar support that has vertical and horizontal translation
2. Seat inclination should be maintained at a 100 degree angle to reduce cervical acceleration-deceleration injuries.[8,9,10]
3. The lumbar support should be approximately in the shape of an ellipse and should be applied at approximately 5cm at the top of the postereoinferior iliac spine area of the pelvis; this will result in the sitting lumbar curve of the driver to be nearly identical to the standing spinal model predetermined by other studies.[11,12,13,14,15]

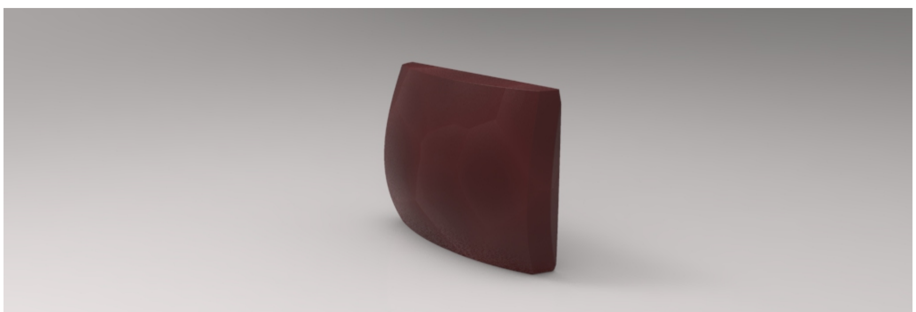


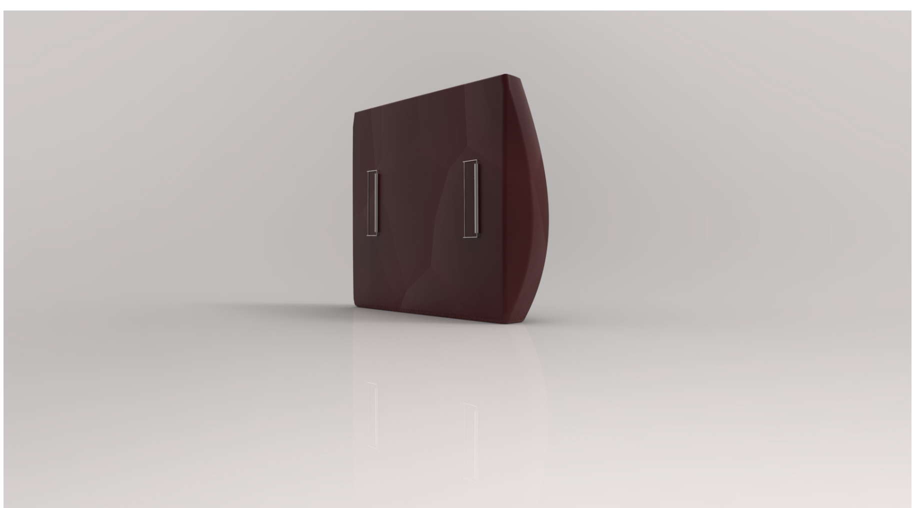
Changing the backrest angle from 120° to 100° and thigh-horizontal angle (seat bottom incline) from 15° to 5° reduces head flexion from 30° to 10°.



Normal sitting spinal model in an ideal driver's seat.

3 Product Renders





4 Competitive Analysis

Analyzing our final product against the current products in the market, the major benefits are:

1. The cushion can be moved in the vertical direction to accommodate for drivers of different heights.
2. The clamping mechanism prevents the cushion from shifting out of place while allowing the driver to adjust his/her posture periodically while driving.
3. The belt mechanism allows the cushion to be easily retrofitted in various vehicles in the low-mid cost segment.

The shortcomings of the current design when comparing it with its competition are:

1. There is no mechanism to alter the rigidity of the cushion to suit the user's needs.
2. The belting mechanism fails in very rare situations wherein there is no allowance between the headrest and the car seat.

5 Scope of Future Work

Once the prototype is done, we plan to do a contour plot with pressure sensors of the cushion with a normal person using it. This will help us verify the effectiveness of the cushion and provide us with areas of improvement of the system. The design shall also need to be tested for versatility and modularity in various car seats. Integrating the stiffness variation is also a major goal and needs to be achieved before the final design iteration.

We also plan on making a model human based on the target Anthropometry so as to test the product against a wider range of users and also to get a better understanding of the target dimensions. It will also help us in deciding whether one product size would be able to cater to the target audience or we would have to come up with multiple sizes of the lumbar support to satisfy the market.

Finally, the lumbar support is to be mass produced using memory foam for the cushion, stainless steel for the clamps and high tension rubber for the belt.

6 Conclusion

In conclusion, the lumbar support is designed to correct the posture of drivers while providing them with a comfortable driving experience. It is designed to be fitted onto car seats of all sizes and also has a degree of freedom in the vertical direction, which helps diverse users use it comfortably. The proof of concept shows that the impact of the lumbar support is significant in reducing the load on the lower spinal region. The survey conducted amongst a small user base shows that the problem is a relevant one for car drivers as well, most of whom have an incorrect driving posture. They are also willing to buy a low cost supplement for their existing car seats to address this problem.

Hence, it is a highly relevant problem that the presented solution is perfectly poised to address, and further development and finally production of the lumbar support would be highly profitable. The unique curvature of the support, the height adjustability and the low cost are the main USPs of the product, which make it stand out amongst the various other offerings in the market.

7 References

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