Lumbar Support Cushion to Provide Continuous Passive Motion

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BME 200/300
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Abstract

This paper explores a number of different options for the design and implication of a lumbar support cushion. This cushion will provide support to the lumbar portion of the back, as well as provide continuous passive motion to the patient. The support cushion is designed for use in automobiles and will have the capability to adjust the cycles of the continuous passive motion.

Problem Statement:

To design a lumbar support cushion that supplies continuous passive motion to the lumbar spine for a variable duration of time when a patient is in a sitting position such as driving an automobile.

Description of product function:

This cushion will provide support to the lumbar region of the back. In doing this, the cushion will properly align the patients back while sitting so that they experience less pain and discomfort. Along with providing support, this cushion will provide continuous passive motion, meaning that it will be in continuous motion throughout the lumbar region of the back. Also, a wedge may be used for the patient to sit on in order to properly align their pelvis, which would greatly help in aligning the lumbar spine.

Client's statement of product requirements:

After meeting with our client, our group found that there are a number of different requirements that the client wants implemented in the final design. First of all, the product must provide proper alignment to the lumbar spine, otherwise the device is useless. Also, the product needs to provide continuous passive motion. There are already lumbar supports on the market that do not provide continuous passive motion, so the motion is necessary. In addition, the entire unit must be easy to use and set up. The more difficult the product is to set up and operate, the less likely the patient is to actually use the product. Lastly, the product must be able to operate in an automobile. This

means fitting in the seat as well as using the available power source. Also, the entire unit must not be a distraction to the driver of the automobile.

Background information:

Since humans evolved from animals that walk on all four limbs, their spines are not very well adapted to sitting. In particular, the lumbar region of the back (the five vertebrae between the rib cage and pelvis) tends to conform to the shape of the seat that the patient is sitting in, which often causes pain and discomfort due to this unnatural position. Along with sitting in an uncomfortable position, the length of time sitting in one position often causes pain. The lumbar region is especially flexible in 25-40 year-olds, which causes pain and discomfort while sitting for extended periods of time. One particular seat that tends to cause a lot of lower back pain is the front seat in a car. Most front car seats are bucket seats. This troubles people with lower back problems because when the knees are above the hips, as is when sitting in a bucket seat, a lot of pressure is put on the lumbar region of the spine. Along with applying pressure to the lumbar region, sitting in a car seat for long periods of time adds to the pain and discomfort.

Alternative solutions:

In order to correct the problem of the patient's hips rotating while in the car seat, a wedge can be placed on the seat. This allows the passenger to sit with his/her knees in a healthy position in relation to the lower back. It also makes it possible for a cushion to rotate the pelvis forward when it is expanded. The wedge is a simple design and can be made of stiff foam or other semi-rigid material. Depending on the size and depth of certain bucket

seats, pieces may be added to the wedge to make it bigger or smaller. Actually, it would just increase or decrease the angle of the wedge to compensate for the depth of the seat.

Single-bladder Air Cushion

Our first design of a lumbar support cushion is a single bladder air cushion. It's a basic idea of having a compartment roughly the size of the lumbar region of the spine expand upon inflow of air and deflate when the air is released. The power supply is still in question because there are many obstacles to overcome. This design would supply continuous passive motion by regulating the rate of inflation and deflation at specific intervals through a switch operated by the user. A timer would establish the cycle of inflation and deflation. This device would be attached to the seat would be attached by elastic straps that would fit around the seat.

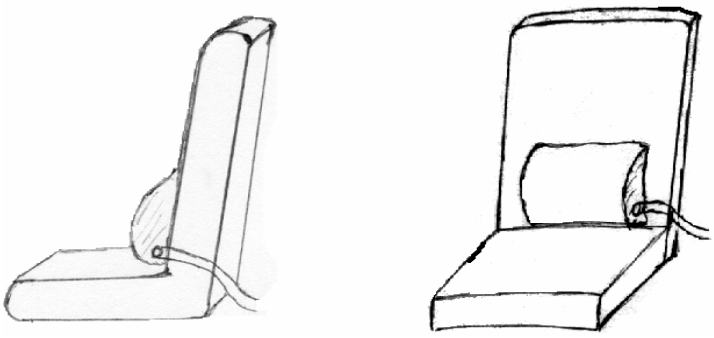

Figure 1 – Single bladder air cushion.

Multi-bladder Air Cushion with Assorted Attachments:

There are two alternatives to this particular design, with the overall purpose of providing continuous passive motion to the lumbar region of the back. Both of the designs incorporate 12-inch long cylindrical air bladders that range in their diameters. These

bladders have an air hose attached at one end and Velcro sewn on one side running the length of the bladder. The purpose of the velcro is for attachment so that the user can rearrange the different sizes to contour to his/her lumbar region. Also, this option allows the patient to change their type of back therapy from day to day. There are two options that these air bladders can be attached to, either a strip of Velcro (roughly 1 ft by 1 ft) that will be strapped to the seat or an existing lumbar cushion. These two alternatives are seen in Figure 2. The air pump will have multiple attachments for air hose hook-up so different sized bladders can be used interchangeably. The different air bladders will inflate and deflate at different times in order to supply greater continuous passive motion, providing a massage to the back.

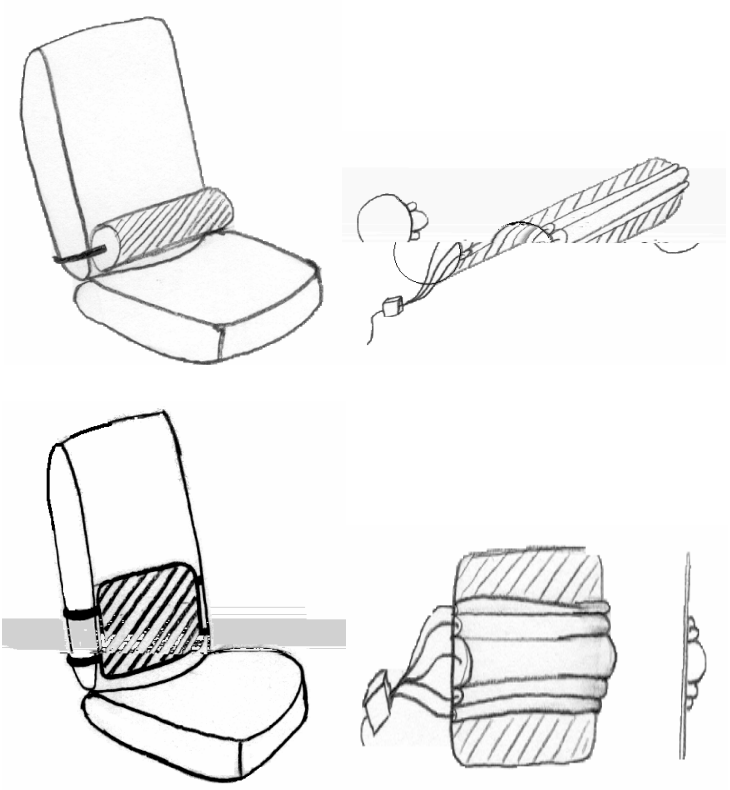

Figure 2 – Two options for the multiple bladder air cushion.

Mechanical oscillating roll design:

The third design for this problem does not use air pressure at all. Instead, a support cushion is placed between two tracks and oscillated up and down, through the lumbar region of the spine. Two small motors within the lumbar support will achieve this oscillation. These two small motors will rotate gears, which will follow the track up and down through the lumbar region. In order to make sure that the weight of the patient does not stop the support cushion from moving up and down, the entire unit will be encased in a shell that has very low friction on the inside to the support can move freely. The small motors would be powered by the cigarette lighter of the automobile. The patient would be able to control the speed of the support cushion through a switch that limits power to the motor, similar to a potentiometer. By adjusting the power to the motors, the device would be able to oscillate at variable speeds. The entire device would be attached to the car seat by Velcro straps; which would wrap around the back of the seat for easy attachment and set-up.

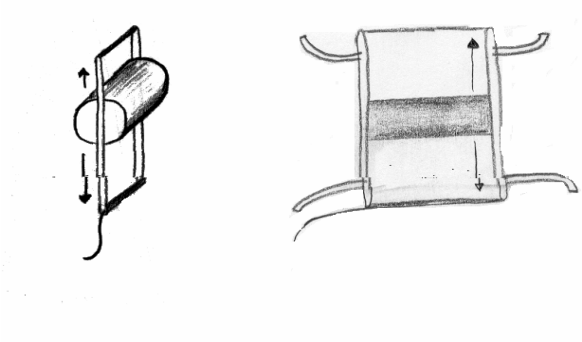

Figure 3 – Mechanical oscillating roll.

Proposed Solution:

Our proposed solution incorporates two of our design alternatives. First of all, we are going to use the wedge beneath the patient to provide correct alignment of the pelvis, hips

and knees. This would be made of a hard foam or soft plastic for patient comfort. The second portion of the design will use the multiple bladder air cushion attached to an existing lumbar support cushion. The support cushion will be held in place with elastic straps that wrap around the seat. The air pump will have multiple attachments for air hose hook-up so different sized bladders can be used interchangeably. This design was chosen because of the large amount of options that the user has while using it. Also, this design will be easy to set-up and use while driving.

Potential problems and possible resolutions:

One of the main problems that all of these designs are facing is the type of motor or pump to use. Since the ideal situation is to use the cigarette lighter of the car, more research need to be done to determine if this is possible. The air pumps that we have found so far are quite loud, so they would be a distraction to the driver. Also, the existing pumps are not able to vary their speed, so they would always inflate at the same rate. Another potential problem is getting the different air bladders to inflate at a staggered rate.

Future Work:

During the rest of the semester, we will look into finding a pump that is quiet and has a variable speed. We will also find out what materials need to be used for the air bladders. Also, we will figure out a way to efficiently connect the air fittings that need to be attached for the device to run efficiently. Once we have all of this information, we will construct a prototype and present it to our client for suggestions and/or changes for the actual product.

Appendix #1:

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Product Design Specifications

Title: Adjustable pneumatic lumbar support cushion with passive motion.

Function: To design a lumbar support cushion that supplies continuous passive motion to the lumbar spine for a variable duration of time when a patient is in a sitting position such as driving an automobile.

Client requirements:

- Provide passive motion to the lumbar region of the spine.
- Not be distracting to the driver or difficult to operate.
- Be comfortable and ergonomic.
- Be adjustable to different automobile seats and batteries.
- Use cigarette lighter as power source if possible.

Design requirements

1. Physical and Operational Characteristics

a. *Performance requirements*: Easily operated while driving and use 12 V cigarette lighter socket, car battery or battery pack. The pump should also be quiet. Bladder should be able to withstand roughly 300 mmHg of pressure and be large enough to provide motion to the entire lumbar region.

b. *Safety*: Must not distract driver in any way or put too much pressure on lumbar spine. Components of pump must be self-contained and safe.

c. *Accuracy and Reliability*: Must provide support to the lumbar spine. Timer cycles must be fairly accurate (±10 sec).

d. *Life in Service:* too be determined

e. *Shelf Life*: too be determined

f. *Operating Environment*: Must operate within an automobile, broad temperature range while not in use (incase patient leaves device in car).

g. *Ergonomics*: Controls should be easy to use.

h. *Size*: Cushion must be able to attach to a car/truck seat and be large enough to provide support to the entire lumbar region of the spine. Pump must fit into center console so that it is out of the way and not a distraction.

i. *Weight*: Light enough for easy transport and installation into different vehicles.

j. *Materials*: Materials should be non-hazardous and not be dangerous to touch.

k. *Aesthetics, Appearance, and Finish*: Should be professional looking, like any other medical device.

2. Production Characteristics

a. *Quantity*: One (prototype)

b. *Target Product Cost*: Unknown, depends on materials used and available funds.

3. Miscellaneous

a. *Standards and Specifications*: Needs to be certified as safe to use while driving.

b. *Customer*: Patients using this device will have lower back pain, usually between the ages of 25-40.

c. *Patient-related concerns*: Must be easy to use, install and move from vehicle to vehicle. Also must be supportive, comfortable and non-distracting while driving.

d. *Competition*: Lumbar support cushions already exist, but none are known to provide continuous passive motion.