

PREDICTING STRATEGY OF LUMBAR BELTS MECHANICAL PERFORMANCE AT DESIGN STAGE

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INTRODUCTION

Low back pain is a pain felt in the lumbar region of the spine. Among a large series of care strategies, lumbar belt might be used to treat this pathology. Several clinical trials have shown the efficiency of lumbar belts [1]. Despite the high quantity of affected patients each year (about 80 % of the French population have /will suffer back pain in their life), few authors investigated the mechanism of action of belts. It is usually reported that the main mechanical effect of a lumbar belt is the pressure applied on the trunk. This pressure on the abdominal skin and muscles induce an increase of intra-abdominal pressure, a decrease of intra-discal pressure, and a proprioceptive reaction of the posture. Unfortunately, the link between the textile characteristics, the belt design and the pressure applied on the trunk has been poorly studied.

Recently, Bonnaire [2] proposed a clinical study using optical methods and pressure map sensors; Munoz [3] proposed a detailed finite element model, closely linked to medical imaging showing the load release in the intervertebral disc, but resorting to a clinical study is a tedious task, and some early stage information should be of great help when designing new belts.

The purpose of this communication is an assessment of the applied pressure by a lumbar belt onto the trunk from the mechanical properties of fabrics and the trunk shape. It gives a way to estimate the mechanical efficiency of belts at the design stage.

METHODS

Global methodology can be explained through the Laplace law: the pressure applied by the lumbar belt on the trunk is proportional to the lumbar belt stiffness, the strain of the belt, and the body curvature. Mechanical properties of the belts are estimated from their components stiffness and the chosen architecture using a simple parallel / series spring model. Body shape is measured using linear triangulation scanner (Orten, France) and derived twice to obtain local curvatures for each specific patient. Here three representative shapes are used, from normal Body Mass Index (BMI) to high BMI. The belt stretch is obtained by comparing the belt length and the body diameter. Last, a feed-back loop is necessary to estimate the body deformation under pressure and therefore the curvature changes.

Because this approach implies a high level of assumptions, some verifications are provided: 4

different belt stiffness are measured experimentally and compared to estimations; reference belts are placed on 3 patients; pressure and strain maps are compared to the calculated one.

RESULTS

The error on the belt stiffness estimation compared with direct measurement on belt is less than 10% for the different cases. Calculated pressure maps give a reasonable average value compared with ground truth experiments, but some local variations have to be investigated better. Last, a typical result is shown on figure 1. The force exerted by the belt at each level clearly shows the bending moment applied to the spine.

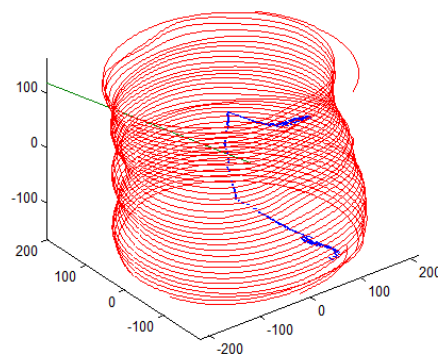


Figure 1: Body shape (in red) and force applied to the trunk, for each level (in blue) and overall force (in green). The patient is a 29 year old man, BMI 38.

DISCUSSION

The proposed methodology helps in designing new belts with low computing time (< 15 min). It can be used at early design stages, previous to clinical studies. The work showed its capacity to discriminate (1) between belts and (2) between patients. Main limitations of the work lies on the numerous assumptions. Detailed fabric behavior or body/fabric interactions would lead to better results.

REFERENCES

1. Calmels et al, Spine, 34: 215–220, 2009.
2. Bonnaire et al, Ann Phys Rehabil Med, 57:e121-e122, 2014.
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