RESEARCH ARTICLE

Driving-induced lower back pain: Investigation of causes and recommendations with TRIZ [version 1; peer review: awaiting peer review]

Poh Kiat Ng¹, Muhammad Syafiq Syed Mohamed², Jian Ai Yeow³

¹Faculty of Engineering and Technology, Multimedia University, Melaka, 75450, Malaysia

²Department of Manufacturing Engineering, Faculty of Manufacturing Engineering, Universiti Teknikal Malaysia Melaka, Durian Tunggal, Melaka, 76100, Malaysia

³Faculty of Business, Multimedia University, Melaka, 75450, Malaysia

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Abstract

Background: Driving-induced lower back pain (DLBP) is associated with long driving times and awkward postures. Nonetheless, its actual causes and solutions remain unclear due to intervening causes from activities of daily living and traumatic injuries. This study investigated the causes and recommendations for DLBP using the theory of inventive problem solving (TRIZ).

Methods: A cause-and-effect chain analysis (CECA) was conducted based on discussions with 19 ergonomics experts from Malaysia. Engineering contradictions were formulated according to the causes and associated with the parameters of the TRIZ system. These parameters were then intersected in the contradiction matrix to extract the inventive principles. Finally, recommendations were made based on these principles.

Results: CECA uncovered the design- and posture-related causes of DLBP. It was implied that missing seat adjustment controls might cause drivers to sit with their knees positioned higher than their hips. This issue causes an excessive posterior pelvic tilt, resulting in DLBP. To address this issue, an inert atmosphere involving the addition of inflatable bubble wraps to elevate the posterior position was recommended.

Conclusion: While there have been studies on DLBP, the present study demonstrated originality by using TRIZ to preliminarily but systematically investigate and resolve DLBP. Further triangulations, prototyping, experimentations, and verifications were not possible due to time and budgetary constraints. Nevertheless, this research uncovered the TRIZ-integrated perspectives on ergonomic solutions to DLBP that are more cost-effective than medical treatments or design overhauls.

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Keywords

TRIZ, lower back pain, driving, posterior pelvic tilt, ergonomics, awkward posture, inventive principles, engineering contradiction

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Corresponding author: Poh Kiat Ng (pkng@mmu.edu.my)

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Introduction

Lower back pain (LBP) involves pain felt below the costal margin and above the inferior gluteal folds.¹ In Australia, the healthcare cost for LBP varies if the patient is admitted to the hospital (AUD\$ 14,949) or discharged from an emergency department (AUD\$ 584).² In addition, LBP also radically changes one's life and identity over time.^{3,4}

Driving-induced lower back pain (DLBP)

While there are findings on the risk factors for DLBP, there is limited evidence supporting that whole-body vibrations directly increase DLBP risks.⁵ DLBP is attributable to accelerated muscle fatigue due to the upright driving posture that is maintained for a long time.^{6,7}

Although improving seat designs limits the effects of DLBP,^{8–11} the causes and solutions for DLBP remain ambiguous due to the presence of outliers from daily living activities. For example, the causes may be complicated due to trauma effects. If a driver sustains injuries from an accident, factors such as airbag deployment and the vehicles involved can affect the pain location.¹² Therefore, it is important to create proper exclusion criteria before exploring the causes and recommendations for DLBP. While DLBP is often researched using surveys,^{13–16} these alone may not sufficiently provide the information needed to address the issue.¹⁷

The theory of inventive problem solving (TRIZ) is an algorithmic problem-solving approach used in various areas, such as technology and business.^{18–21} The use of such a systematic yet adaptable approach in the context of DLBP has not been explored. Hence, this study aimed to investigate the causes and recommendations for DLBP using TRIZ.

Methods

The exclusion criteria were established first because DLBP is a specific kind of LBP. These criteria were determined through a focus group discussion among three medical doctors who were selected using purposive sampling. Each doctor has had at least 10 years of experience in treating LBP. Based on the discussion, the following criteria should be excluded when deliberating the causes of DLBP:

- Pre-existing back injuries (e.g. herniated disc, prolapsed disc);
- Fractures;
- Overweight or obesity;
- Congenital spine abnormalities (e.g. ankylosing spondylitis, seronegative spondylarthritis);
- Limb deformities (e.g. talipes equinovarus, congenital polio)
- Other health issues (e.g. spinal stenosis, prostate issues);
- Pregnancy;
- Pain from activities besides driving (e.g. sports, sitting in front of a work desk)

These exclusion criteria were referenced in the main focus group discussion. A cause-and-effect chain analysis (CECA) was used, with the causes extracted from the main focus group comprising 19 ergonomics experts from Malaysia who were selected using purposive sampling. Each expert has had at least 10 years of experience in ergonomics and DLBP.

The experts suggested that drivers commonly complain about temporary LBP around the L5–S1 region after driving for 10–15 min due to increased disc pressure caused by a slouched driving posture. This posture is attributable to a posterior pelvic tilt from an increased hip flexion angle when sitting with the hips positioned below the knees. The experts added that this condition occurs if there are no seat adjustment controls for the posterior position. These causes are summarised in the CECA diagram (see [Figure 1](#)).

Results

From the posture-related causes, the first engineering contradiction (EC1) was formulated.

EC1: If the hip is positioned lower than the knees, then the driver sinks his/her weight into the seat (#2: Weight of stationary object), but the increased disc pressure causes LBP (#11: stress or pressure).

Figure 1. Cause-and-effect chain analysis diagram for DLBP.

The “then” and “but” phrases were linked to two system parameters^{22,23} and intersected in the contradiction matrix²⁴ to obtain four inventive principles:

13: The other way around

29: Pneumatics and hydraulics

10: Preliminary action

18: Mechanical vibration

Preliminary action (essential change on the object before needed) was found to be suitable for resolving EC1. Specifically, seat controls can be used to elevate the posterior portion before driving²⁵ for the hips to be positioned above the knees, thereby preventing the risk for LBP. However, some vehicles do not have this type of seat control. For this design-related cause, the EC2 was formulated.

EC2: If the seat controls are omitted, then the cost is reduced (#39: Productivity), but a compromised sitting posture causes LBP (#13: Stability of the object’s composition).

Similarly, the parameters were intersected in the matrix to obtain these four principles:

35: Parameter changes

3: Local quality

22: Blessing in disguise

39: Inert atmosphere

An inert atmosphere (adding neutral parts or “nothing” into a system) is suitable for resolving EC2. Adding “nothing” can include adding air (e.g. inflatable bubble wraps to elevate the posterior position and alleviate disc pressure).

Meanwhile, a hard object is not suitable because it causes discomfort and pain around the waist and buttocks.^{26,27} Conversely, a soft object is not suitable as the driver will sink into the seat, negating the original purpose of the solution.

Apart from that, a soft high-density foam is also an option.²⁸ The object should be hard enough to prevent drivers from sinking back into the original posture and soft enough to maintain cushioning.

Conclusions

This study preliminarily investigated the causes and recommendations for DLBP using TRIZ. This aim was achieved using the CECA and inventive principles. Although DLBP has been studied previously, the present study demonstrated originality by using TRIZ to preliminarily but methodically investigate and resolve DLBP.

CECA revealed that DLBP arises from sitting with the hips positioned lower than the knees or without seat controls. The preliminary action principle proposed that seat controls should be included in the seat design to allow the lumbar region to be elevated and reduce the posterior pelvic tilt. Considering that not all cars have these seat controls, the inert atmosphere principle was recommended by adding inflatable bubble wraps to elevate the seat’s posterior portion. In summary, rapidly-synthesised and cost-effective solutions for DLBP were successfully proposed using TRIZ.

Limitations and future directions

This was a preliminary study. Triangulation, prototyping, and experimentation were not possible due to time and budgetary constraints. In the future, further apparatus development and testing should be considered.

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Author contributions

Poh Kiat Ng

Roles: Conceptualisation, data curation, formal analysis, investigation, methodology, project administration, writing – original draft preparation, writing – review, and editing

Muhammad Syafiq Syed Mohamed

Roles: Conceptualisation, investigation, project administration, writing – original draft preparation, writing – review and editing

Jian Ai Yeow

Roles: Project administration, methodology, writing – review and editing

Ethical approval

Ethics approval for this study was granted by the Technology Transfer Office of Multimedia University (approval number EA2882021).

Consent

Written informed consent was obtained from the participants in the preliminary and main focus group discussions.

Data availability

Figshare: Driving-induced lower back pain: Investigation of causes.

DOI: <http://doi.org/10.6084/m9.figshare.14754150>.²⁹

This project contains the following underlying data:

- Summary of Focus Group Discussion Data.docx. (This contains data on the points, opinions, and information from the preliminary focus group discussion meant to establish the exclusion criteria and from the focus group discussion that aimed to establish the causes of driving-induced lower back pain).

Data are available under the terms of the [Creative Commons Attribution 4.0 International license](#) (CC-BY 4.0).

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