

Conceptual Analysis of Lower Back Pain Resulting from Awkward Sitting Posture in Driver Vehicle Seat—Systematic Review and Surveys

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Abstract

This research paper presents an analysis of the different kinds of pains in particular lower back pain (LBP) which result from the awkward sitting position of the driver. The analysis is conducted through library research and field surveys of respondents. The research methodology adopted is content analysis with systematic reviews of relevant related scientific journals since the research study is from the conceptual approach. In addition, the data from the surveys will also be used to strengthen the justification of this research outcome and its hypothesis. The objective of this research paper is to identify the various main types of pain suffered by drivers resulting from sitting in an awkward posture in the car seat either during driving or stationary mode with the ultimate aim of determining the most dominant and prevalent pain, namely low back pain (LBP) in relation to the sitting postures of drivers. With this research knowledge content, it is able to help develop measures for the transport car manufacturing industries and policy makers for the driving industry to reduce ergonomic risk of low back pain (LBP).

Keywords

Awkward Posture, Driver Sitting Posture, Musculoskeletal Disorder, Lower Back Pain

1. Introduction of Research

Driving has indeed put a great amount of work effort into performing the task. While doing the driving task, the driver is subjected to multiple multitudes of risks, particularly ergonomic risks. Ergonomic risks include causing pains and

injuries to the drivers whilst driving, especially during a prolonged period of sitting in the vehicle's car seat. Hence, it is of utmost importance to perform an analytical and conceptual study on this subject matter. One of the dominant and pertinent muscular pains that drivers suffer is low back pain (LBP) due to the awkward sitting position prevalent in vehicle car seat. Sarah Tinitali *et al.* [1] have established that there is correlation between occupational driving causing low back pain (LBP). Thus, this research paper aims to further ascertain the various muscular injuries with regards to occupational driving and whether the most dominant muscular injury from drivers is low back pain (LBP) and to establish the correlation and coexistence between LBP and the awkward sitting posture of drivers. A systematic review is conducted in selected scientific journals on the related research topic of LBP and driver sitting posture. A short brief survey was developed, and a sample size of about 1000 drivers was enrolled into this survey participation to determine whether low back pain is the main muscular injury during driving. Besides the conceptual analysis approach of this research, the surveys help to further strengthen the findings of this research.

Two established scientific journals that are very similar in research area, are systemically reviewed in depth to support the objective and hypothesis of this research paper and most importantly to initiate this very own research to be pursued further, namely by Halek, R. *et al.* (2023) [2], paper entitled "Ergonomic Risks on Driver's Posture Interface"; and by Chen, H. and Chen, H. and Wang, L., (2019) [3], paper entitled "Analysis of Vehicle Seat and Research on Structure Optimization in Front and Rear Impact." The first paper by Halek, R. (2023) encapsulates the existence of ergonomic risks that prevail for drivers in sitting static posture. The hypothesis proves that ergonomic risks exist amongst drivers from different demographic parameters when these drivers sit in the car seats. However, the findings did not explicitly determine the exact part of the body pain that resulted in the ergonomic risks. Thus, the need to examine other research papers that focus on low back pain injury in driving. Nevertheless, Halek, R. (2023) research paper is a good start for the onset of this research to be pursued further to examine and study further to establish the most dominant and prevalent pain of the body posture and body part in driving activity. On the other hand, the other paper by Chen, H. and the team furnished us with a different perspective of research, in which seat design optimization is examined and experimented with. The end result indicated that the optimized seat improved the occupant protection performance by reducing occupant damage parameters compared with the original seat, which illustrated that the optimization basically met the target. The result is an indicator that driver will suffer injury if the seat is not in the optimized conditions to suit the body posture of the driver. Hence, both of the main research papers, establish the correlation between driver posture in sitting position with the related body injury. Therefore, the need for this research paper aims to establish the main dominant injury that prevails for drivers.

2. Systematic Literature Review & Surveys

The systematic review of this research encapsulates the process of systematically reviewing literatures, in the coverage of research areas in occupational driving ergonomic risks and its related occupational injuries, namely low back pain (LBP). It is of paramount importance for this research to unveil the various illustrations of occupational health injuries resulting from the occupational driving task from the variety of source references as evidences from the library research approach. The focus of this literature systematic review is not only the comprehension of the various occupational injuries and different driving postures resulted from occupational driving due to sitting posture but also to determine the most prominent and dominant occupational injury from all the sources gathered in particular all scientific journals in relation to the topic in research in relations to LBP.

One of the main occupational health issue resulted from occupational driving is low back pain (LBP). Low back pain describes the pain between the lower edge of the ribs and the buttock according to World Health Organization (WHO) (2024) [4]. WHO further explains that LBP can last for a short time (acute), a little longer (sub-acute) or a long time (chronic). LBP makes it hard to move and can affect quality of life and mental well-being. It can limit work activities and engagement with family and friends. LBP can be specific or non-specific as stated by WHO. Specific LBP is pain that is caused by a certain disease or structural problem in the spine, or when the pain radiates from another part of the body. Whereas, non-specific LBP is when it isn't possible to identify a specific disease or structural reason to explain the pain. LBP is non-specific in about 90% cases. According to WHO, an estimated 619 million people live with LBP and it is the leading cause of disability worldwide. LBP is a major public health issue. LBP is often associated with loss of work productivity and thus produces huge economic burden on individuals and on societies.

The existence of LBP amongst drivers is evident from the research paper journal from Sarah, in which, her research demonstrated the relationship between occupational driving sitting posture and low back pain. Sarah managed to establish this relationship and correlation but with several limitations. Her review has found that there is evidence to demonstrate a relationship between occupational driving posture and low back pain. However, this evidence is based on studies incorporating bias due to the use of measurement tools lacking validity and reliability. Sarah elaborated that four of the seven articles reported an association between driving posture and low back pain, and thus, it could be implied that a relationship exists between these outcomes; however, the specific postures associated with low back pain and the strength of the relationship between these outcomes are not yet known.

Many of the included studies reported the use of validated tools to measure low back pain and driving posture; however, on closer inspection, it was apparent that this was not the case. Several papers made modifications to previously

formed questionnaires without reporting the validity of the modified tool or formed new questionnaires that did not undergo validity testing. According to Sarah, four of the seven eligible articles reported a relationship between some dimension of driving posture and low back pain. The postures reported to be associated with low back pain were, at times, contradictory, with both “driving with back in a bent or twisted posture” and “driving with the torso against the backrest” associated with current low back pain and history of low back pain in the last 12 months. This evidence therefore brings to a question whether are all of these driving postures associated with low back pain, or is further clarification or classification required about driving posture. The diverse methods by which posture has been measured and analyzed by the eligible articles scientific journals and the varied postures reported to be associated with low back pain demonstrate the need for tools that measure driving posture in a quantitative way. Quantitative study involves a more vigorous method of satisfying the evidences gathered to prove the hypotheses through the quantification process. Nevertheless, Sarah article proves the existence of LBP in driving no matter what method of measurements are adopted.

The main gist of this research study is to determine which body part demonstrate the most pain when an awkward posture is adopted in the sitting position of a driver. There are two position that can be look for in such situation, namely a static posture and also a dynamic posture. A static posture is when the body is in static position whilst in dynamic posture, the body is in motion, *vis a vis*, together with the car in motion while driving the vehicle. Due to the limitation of this study, the research covers only the static posture. However, this research paper will also cover those research literature journals that cover dynamic posture due to again, the limitations of research in static posture. The main part of the body that will be examined is the upper body part which includes the body back posture, the neck, the shoulder and the upper arms. A systematic review process is adopted in this research not only to study and determine the most dominant pain of upper body in drivers, but also be supplemented with surveys from respondents of drivers to ascertain that the most dominant pain of LBP is true.

Turney S. (2023) [5] defines systematic review as a type of review that uses repeatable methods to find, select, and synthesize all available evidence. It answers a clearly formulated research question and explicitly states the methods used to arrive at the answers. A total of 10 scientific published journals had been selected revolving around the said research topic of LBP in driving and its related research hypotheses. All these journals are carefully examined and evaluated in terms of its outcome, results, method used and most importantly systematically reviewed to arrive in the conclusion of this research paper on its hypotheses proving and justification. The survey for the respondents covers questions from the most dominant pain of the body part encountered during driving and also in static position, to question of rating the pain rate for the most dominant pain for

that part of the body. Hence, the intensity of the survey questions, lingers around the notion of the pain of the upper body part of the driver and also the adaptation of the body posture in the seat of the vehicle. The data collated from these surveys will prove and support the systematic review evidences so that a holistic approach is perform for this research work from the conceptual analysis perspectives.

3. Research Objectives, Hypotheses and Rationale

Both research objectives and hypothesis are formulated and developed to ensure that the research works progress in alignment of the appropriate line of objectives to ensure targeted consistency and relevancy.

The overall research objectives are:

- 1) To perform a systematic review, literature study and content analysis of published journals to determine the most dominant pain namely low back pain (LBP) due to driver static sitting posture position in the car seat.
- 2) To conduct surveys on drivers to find out whether which part of the body posture pose the most pain whilst sitting in the car seat and determination of correlation of low back pain with different sitting postures in particular awkward sitting posture.

Hypotheses*:

H1—Drivers sitting in car seat posture will result in low back pain (LBP) as the dominant pain injury in driving.

H0—Drivers sitting in car seat posture will **NOT** result in low back pain (LBP) as the dominant pain injury in driving.

*Note**—Hypothesis is established based on assumption that all other parameters or variables remain constant and no other confounding variables available.

The rationale of this research is to unveil the most dominant pain encountered by drivers due to their sitting posture in the vehicle car seat so that a proper analysis and examination can be done further on the correct sitting posture and elimination of the ergonomic risks. This in turn will help the car manufacturing industries to design a car seat which is more ergonomically friendly and an education coaching mechanism framework to be developed to train and coach future drivers the correct sitting posture which can totally eliminate these ergonomic risks.

4. Research Methodology

The research method adopted in this research work is by way collective content analysis in the major attempt with blending of surveys done from the test sample subjects. The analysis of the content is taken from various source references in particular research journals in relation to the topic in research which is namely determining the various ergonomic injuries namely LBP resulting from the driver sitting postures and determining which part of body parts resulted in the most body pain due to the sitting posture. In addition, surveys will be done to support

the findings of the content analysis research work. Surveys of about 1000 private-hire drivers will be done for this research. Private-hire drivers are selected because they are highly exposed to ergonomic risks whilst performing their work to drive their cars daily and sitting in the static posture most of the time. In Singapore, the total population of private-hire drivers is about 76,686 (Straits Times, 2023) [6]. Statistically, a good sample size of 10% is chosen from the population, but if it exceeded 1000, then the maximum sample size of 1000 is chosen based on a sound statistical approach. In this case, the sample size of 10% of 76,686 is approximately 7669, which exceeded 1000, hence the final sample size chosen for the surveys is 1000 private-hire drivers. The surveys will cover questions, not exhaustively, ranging from the duration of sitting position in the car seat, driver adopted sitting posture, various identification of body parts that cause the pain when in that sitting posture, rating of pain, most dominant body part pain for the awkward posture, and reasons for the poor adoption of sitting posture.

The other attempt to consolidate all relevant scientific journals related to ergonomic driver sitting posture and its related ergonomic bodily injuries is to justify the fact that ergonomic risks prevail and the research attempts to prove the evidence that which part of the body causes the most dominant pain. The scientific journals are carefully selected to be in relation to the close proximity of the research work. In addition, these scientific journals are also to be evaluated, analyzed, scrutinized and constructively critiqued to enable to phantom the gist of the topic revolving the research work. Quality of these scientific related journals are more important to be focus rather than the quantity of them. The most relevant literature and related research will be selected to be examined and evaluated on its relevancy, reliability and validity so as to ensure that the systemic reviews of all the scientific journals are justified. The research methodology used for these selected scientific journals will also be scrutinized and reviewed in order for the justification of the findings and data collected to be realistic and again justifiable for the conclusion of this systematic review process to take place. In total, about 10 related scientific journals will be selected and systematically reviewed in order to meet the research objectives.

5. Findings and Data Analysis

The data collated from the systematic reviews from all the 10 related scientific journals are examined and evaluated comprehensively and thoroughly. The 10 related scientific journals are sourced from the related topic of ergonomic risks on sitting posture of drivers especially awkward posture that resulted in the body pain in particular the upper body portion of low back pain issue. One of the scientific journal systematically reviewed is entitled “Sitting Posture During Occupational Driving Causes Low Back Pain: Evidence-Based Position or Dogma? A Systematic Review”, written and authored by Sarah Tinitli, Kelly-Ann Bowles, Jennifer L. Keating and Terry Haines from the Monash University, Melbourne, Victoria, Australia. The objective of their research work is to determine if there

is evidence to demonstrate a relationship between occupational driving posture and low back pain. The paper reviews the current literature pertaining to the relationship between occupational driving posture and low back pain. In addition, the paper review found that four out of the seven eligible articles reported a relationship between these outcomes, however, this was based on measurement approaches with unknown validity and reliability. Although this paper's research work proves the coexistence of the relationship of the driving posture and low back pain, but further studies using valid and reliable, quantitative and real-time measurement techniques are required before the overall result outcome can be concluded. However, the research supported the hypothesis for establishment and correlation of low back pain resulting from awkward sitting posture of drivers. Thus, the outcome of the research justifies the correlation of sitting posture of drivers with the resulted ergonomic injury which shows that low back pain as the dominant injury.

The other scientific published journal is written and authored by Toshihiko Sakakibara, Yuichi Kasai and Atsumasa Uchida (2006) [7], entitled "Effect of driving on low back pain". Toshihiko's research dwelled into the investigation of how driving affected the occurrence of lower back pain (LBP) in medical representatives. The overall of the result outcome indicated that there is significance indication that the medical preventatives suffered low back pain during driving. Published scientific journal by Ayman *et al.* (2022) [8] supported the correlation of low back pain and driving. Ayman's journal on "Prevalence of lower back pain and its relationship with driving posture among drivers in Taif, Saudi Arabia", indicated the results of prevalence of low back pain amongst drivers in Taif. The analysis of Ayman's research works showed that the prevalence of lower back pain in the study was about 44.1% ($n = 659$). When Ayman research team assessed the relationship of LBP with the age of the participants, it was found the prevalence of LBP was more among those aged >40 years (50.9%) compared to other age groups, which showed a statistically significant association ($P < 0.001$). Married people had a significantly higher prevalence of LBP than unmarried ($P < 0.001$). LBP was significantly higher among those who were driving for 10 - 15 years (48.2%) and more than 15 years (47.4%) ($P = 0.003$). Wrong posture and poor asphalt were significantly associated with LBP ($P < 0.001$). The LBP prevalence was found to be comparatively more among those who drive slowly ($P < 0.001$). Thus, it can safely be concluded from Ayman's research that the most dominant pain suffered by drivers is the low back pain (LBP) with adaptation of poor posture.

Another published paper by Chen *et al.* (2024) [9] suggested the same outcome in the paper entitled, "Prevalence of low back pain in professional drivers: a meta-analysis". The objective of the paper is to investigate the prevalence of low back pain (LBP) in professional drivers. The research design is a meta-analysis approach. Various methods adopted including, not exhaustively, example like: PubMed, Scopus, Embase, and Web of Science were searched for cross-sectional

studies on the prevalence of LBP in professional drivers up to August 2023. The Agency for Healthcare Research and Quality was utilized for cross-sectional analytical studies. Statistical analysis of the included outcome indicators was conducted using Stata 16.0. The prevalence of LBP among professional drivers was measured using the random effects model, and heterogeneity was evaluated utilizing subgroup analysis. The meta-analysis review was registered with PROSPERO on April 28, 2023, under the registration number CRD42023422205. The final results obtained: In total, 1558 results met the inclusion and exclusion criteria, and 53 studies were included. The meta-analysis results indicated that professional drivers had a LBP prevalence of 35.0%, 95% CI (0.266, 0.433) for one week, 33.80%, 95% CI (0.233, 0.443) for one month, and 55.30%, 95% CI (0.503, 0.603) for one year. In the global population of professional drivers, the prevalence of LBP was 56.0%, 95% CI (0.472, 0.648) and 54.5%, 95% CI (0.488, 0.602) without and with a history and high risk of LBP, respectively. Conclusion from this paper unveil that LBP remains prevalent among international drivers and has multiple contributing factors, highlighting the urgent need for increased awareness and prevention strategies.

The reinforcement of the overall results of low back pain occurs dominantly in driving is the paper published by Poh Kiat Ng, Muhammad Syafiq Mohamed and Jian Ai Yeow (2021) [10], entitled “Driving-induced lower back pain: Investigation of causes and recommendations with TRIZ.” 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. The study conducted by Syafiq and team investigated the causes and recommendations for DLBP using the theory of inventive problem solving (TRIZ). The method of 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. The results of 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, Syafiq and team introduce an inert atmosphere involving the addition of inflatable bubble wraps to elevate the posterior position was recommended. 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, the research uncovered the TRIZ-integrated perspectives on ergonomic solutions to DLBP that are more cost-effective than medical treatments or design overhauls. The abstract and gist taken from this

research work proves the existence of the low back dominant and prevalence pain due to driving using the different approach method of investigation.

The rest of the other remaining 6 scientific published journals which is related to the study and research of low back pain in driving, also signifies the conclusion that there coexists a correlation between low back pain (LBP) and driving posture. Even though there are limitations of the research work on the measurement and experimentations of body posture in driving and its related injury of lower back pain, the shortfall does not prevent the overall hypotheses of justification of the dominant and prevalence of low back pain as an ergonomic risk existed during driving and also in sitting static position in the driver's seat. This is evident from all the 10 scientific journals evaluated and systematically reviewed that all the journals agree on the existence of the low back pain as dominant and prevalent. The only difference between these journals is the method adopted in measurement of the body posture in sitting as a driver and also the different articulation made between these journals due to their differential factors included in their study. It can be safely and confidently justified with positive assurance that the dominant pain in driving with awkward posture adopted is the low back pain.

On top of the systematically reviewed process of the scientific journals, the additional evidence to conclude and prove the hypothesis of the dominant pain in driving, is the surveys conducted amongst the 1000 private-hired drivers. Again to reiterate the importance why these private-hire drivers are selected in the survey process, is because of their dominance amongst drivers in the road in Singapore and they spend prolong hours on the road driving and long hours' exposure sitting in the vehicle car seat during their working hours. The survey questions ranges from asking these drivers on their pain of body part to the intensity of this pain on that particular location. The pain is rated from 1 to 10. An indication of body posture was illustrated in the survey, and the respondent need to circle which part of the body posture that they feel pain. The other prevailing question is the posture that they adopted while sitting in the car seat. Three different photos are given for them to choose from in which one extreme shows a good sitting posture and the other extreme is to show awkward sitting posture. Data from the surveys are collated and analyzed comprehensively.

The results from the surveys indicated that 95% of the respondents surveyed agree that the most dominant and prevalent pain is the low back pain whilst in the sitting posture of the driver seat. While 88% of the respondents agree that awkward adaptation will lead to the result of low back pain. 75% of the respondents rated a high pain intensity of 8 out of 10 rate marks. 98% of the respondents showed awkward posture adaptation for their driving posture. All these data survey figure results indicated and signified the prevalence and dominance of pain of the low back posture during driving and in static seating position of the drivers. Thus, the research objective has been achieved by the indication of the survey results that illustrated the most dominant pain is the low back pain and its prevalent amongst drivers adopting awkward posture. The demo-

graphic of the respondents is not into consideration for this research because the research hypothesis is not for the justifications and research understanding of any parameters for demographic profile but only the need to prove the existence of dominant pain in drivers regardless of any demographic profile such as gender, age, driving experience and so forth.

6. Conclusions & Recommendations

In conclusion, the most dominant and prevalent pain for drivers is the low back pain (LBP) for their driving experience sitting in a static position in the vehicle car seat. The systematic reviews conducted for all the related scientific journals published have proved and justified the said hypothesis of adopting awkward driving posture resulted in low back pain for drivers. Besides the process of systematic reviews of the literature and various related research work, the other evidence gathered to prove the hypothesis of H1, is that of the data collation of surveys done for the 1000 drivers selected and responded. A high score of above 90% from the respondents from the surveys conducted, indicates that the dominant pain is the low back pain in the driving posture. Thus, overall outcome and conclusion, with both the pieces of evidence from the systematic reviews of scientific published journals and the results from the outcome of the surveys of 1000 drivers, it can be safely and significantly concluded that the hypothesis H1 is supported and that the most dominant pain is the low back pain resulting from awkward and poor posture of driving in the car seat.

One of the recommendations to alleviate the most dominant and prevalent pain is to ensure good sitting posture to be adopted at all times when a driver sits in the vehicle. However, to ensure this recommendation to be applied appropriate, education and coaching is necessary. This initiative could be initiated in driving centers teaching new drivers and existing drivers taking refresher courses, to abide to the culture of adjusting the seat posture to suit the driver posture comfortably to avoid awkward posture sitting arrangement before any driving start. Another recommendation is for car manufacturers to ensure that the design of the seats of the car vehicles are ergonomically designed to eliminate the risks of drivers adopting irregular or improper posture of sitting which could result in incurring dominant and prevalent low back pain injuries. The ergonomically designed car seats can automatically adopt the posture and curvature of the drivers' back posture when they sit in the car seat, thus reducing the need for the drivers to adjust the back portion of the car back rest. Hence, with these two strong recommendations, drivers can have better and more comfortable driving postures and have a pleasant driving experience.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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