

ASSOCIATION BETWEEN SITTING DURATION AND SITTING POSTURE WITH LOW BACK PAIN AMONG BUS DRIVERS TRAVELING BETWEEN BALI AND JAVA

Putu Narda Davina Cahaya Cinta Ariyani¹, I Gusti Ayu Widianti^{2*}, Muliani², I Nyoman Gede Wardana²

¹Bachelor of Medicine and Medical Profession, Faculty of Medicine, Universitas Udayana

²Department of Anatomy, Faculty of Medicine, Universitas Udayana

Corresponding Author

I Gusti Ayu Widianti

Department of Anatomy, Faculty of Medicine, Universitas Udayana

E-mail: widianti@unud.ac.id

E-mail: pndc4hayac1nta@gmail.com

ABSTRACT

Background: Low back pain (LBP) is a pervasive musculoskeletal disorder significantly affecting workforce productivity, particularly in the transport sector. Night bus drivers are theoretically at high risk due to prolonged static loading and non-ergonomic postures. However, the specific contribution of these biomechanical factors remains debated in the context of long-haul driving.

Objective: This study aimed to determine the prevalence of LBP and analyze the correlation between sitting duration and sitting posture with the incidence of LBP among night bus drivers on the Bali-Java route.

Methods: An observational analytic study with a cross-sectional design was conducted involving 68 male night bus drivers selected via purposive sampling. Data regarding sitting duration, sitting posture, and LBP symptoms (measured via the Nordic Musculoskeletal Questionnaire) were collected and analyzed using Chi-Square and Fisher's Exact tests with a significance level $p < 0.05$.

Results: The prevalence of LBP was 36.8%. There was no significant association between sitting duration ($p = 0.650$) or sitting posture ($p = 0.527$) and LBP. Age ($p = 0.947$) and BMI ($p = 0.333$) were also not significantly associated with LBP.

Conclusion: LBP affects more than one-third of night bus drivers on the Bali-Java route. The absence of a significant correlation suggests that sitting duration and sitting posture alone are not the primary determinants of LBP in this group.

Keywords: low back pain, prevalence, sitting duration, sitting posture, night bus drivers.

INTRODUCTION:

Low back pain (LBP) has emerged as a critical global health challenge and continues to be one of the leading contributors to years lived with disability (YLDs). Epidemiological estimates from 2019 indicated that approximately 568.4 million people were living with LBP, alongside 63.7 million YLDs worldwide. In Southeast Asia, the burden remains substantial, affecting more than 54.5 million individuals.¹ Although national prevalence estimates in Indonesia—particularly in Bali—have been reported, there has been no comprehensive population-based research conducted in the past five years. Low back pain (LBP) contributes to significant socioeconomic consequences, including reduced productivity, increased healthcare costs, and a rising trend in disability-adjusted life years over the past decade.

In occupational settings, LBP was commonly categorized as a work-related musculoskeletal disorder (WMSD), as workplace exposures played a significant role in accelerating mechanical strain and musculoskeletal degeneration. More recent analyses emphasized that occupational LBP was influenced not only by physical load but also by psychological and systemic factors, such as stress, sleep deprivation, and lifestyle habits.^{2,3} Bus drivers represented one of the occupational groups with the highest risk, given the combination of prolonged static sitting, limited variability of posture, restricted cabin ergonomics, and long-term exposure to mechanical vibration. Recent studies reported in several Asian countries prevalence rates of 60.4% in Malaysia and 67.4% in India.^{4,5} In the Middle East, up to 73.9% among commercial bus drivers, with even higher rates in drivers aged over 50 years.⁶

In the Indonesian context, the prevalence of LBP among bus drivers also demonstrated considerable variation. Prior studies reported LBP rates of approximately 45.5% among drivers operating 500-km inter-city routes and 53.75% among inter-provincial drivers in Bali.^{7,8} These differences were believed to reflect variations in route characteristics, road conditions, and driver work cycles, including the growing use of relay driving systems on longer routes. Despite this variability, the consistently elevated prevalence underscored the need for continuous occupational health surveillance and targeted ergonomic interventions.

The biomechanical pathway underlying LBP in drivers had been linked to prolonged sitting duration and non-ergonomic posture. Static sitting increased intradiscal pressure, reduced disc perfusion, accelerated fatigue of paraspinal muscles, and limited the spine's natural shock-absorbing capacity.⁹⁻¹³ However, recent literature had argued that the relationship between sitting duration and posture with LBP was not stand alone. Factors such as seat design, posture variability, driving breaks, physical fitness level, and vibration exposure significantly also moderated this association. Large-scale occupational studies between 2020–2024 emphasized that prolonged sitting only became a significant predictor of LBP when accompanied by inadequate microbreaks, poor ergonomics, or low physical activity levels.^{3,14,15}

Despite the established risk profile, limited research had comprehensively examined the combined influence of sitting duration and sitting posture among long-distance night bus drivers in Indonesia, particularly on the Bali–Java corridor. This specific population was exposed to prolonged driving hours, variable road conditions, and operational routines that may differ from short-distance urban routes. Therefore, the present study aimed to determine the prevalence of LBP and to analyze the statistical relationship between sitting duration and sitting posture with the occurrence of LBP among Bali–Java night bus drivers. Understanding these relationships in a contemporary operational context was essential to inform occupational health strategies and ergonomic improvements tailored to long-haul commercial drivers.

METHODS

This research employed an observational analytic design with a cross-sectional approach. This design was selected to simultaneously assess exposure variables (sitting duration and sitting posture) and the outcome variable (LBP) at a single point in time. The study was conducted at the Mengwi Type A Terminal, Badung, Bali, and various bus pool stations from March to June 2025.

The target population comprised all night bus drivers operating on the Bali–Java route. A total of 68 male drivers were recruited using a purposive sampling technique based on specific eligibility criteria.

Inclusion criteria were male drivers operating on the Bali–Java route with a work tenure of ≥ 5 years who provided informed consent. Exclusion criteria were the presence of a history of spinal trauma or fractures, congenital spinal deformities, prior spinal surgery, or systemic diseases known to associated with musculoskeletal pain (e.g., severe diabetes mellitus, osteoporosis, and malignancy).

The dependent variable in this study was LBP, assessed using the Standardised Nordic Musculoskeletal Questionnaire (NMQ), which specifically evaluated LBP symptoms. Participants were dichotomized into "pain" or "no pain" groups based on symptoms experienced during the last 12 months.¹⁶ The independent variables included sitting duration, sitting posture, age, and body mass index (BMI). Sitting duration was defined as the cumulative daily driving hours, categorized into low (< 4 hours), medium (4–7 hours), high (8–12 hours), and very high (> 12 hours). Sitting posture was evaluated via observation and self-report diagrams, classified as either "ergonomic" (supported, reclined backrest) or "non-ergonomic" (unsupported, upright, or kyphotic posture). Covariates included age (stratified as < 40 and ≥ 40 years) and BMI, which was categorized according to the Asia-Pacific guidelines.

Data were analyzed using SPSS version 26.0. Univariate analysis was performed to describe respondent characteristics. Bivariate analysis employed the Chi-Square test and Fisher's Exact test to evaluate the relationship between age and LBP. Fisher's Exact test was utilized for variables (sitting duration, sitting posture, and BMI) where expected cell counts were insufficient (< 5) for Chi-Square validity. Statistical significance was established at $p < 0.05$.

RESULTS

The study included 68 respondents with basic characteristics comprising the presence of low LBP, sitting duration, sitting posture, age distribution, and body mass index (BMI).

Univariate analysis was performed to describe the frequency distribution of LBP as the dependent variable and the independent variables of sitting duration, sitting posture, age, and BMI, thereby addressing the first research question regarding LBP prevalence.

The point prevalence of LBP in this study population was 36.8% ($n = 25$). The majority of drivers, amounting to 63.2% ($n = 43$) reported no significant LBP symptoms.

The demographic analysis revealed that the workforce was predominantly older, with 73.5% of participants aged ≥ 40 years, placing the majority in the higher-risk age category for developing musculoskeletal disorders. Nutritional status based on BMI also showed a concerning pattern, as more than half of the respondents (54.4%) were classified as obese, which may contribute to increased biomechanical stress on the lumbar spine.

Table 1. Low Back Pain Prevalence and Characteristics of Bali-Java Night Bus Drivers

Variable	Frequency (n)	Percentage (%)
Low back pain		
Pain	25	36.8
No pain	43	63.2
Sitting duration		
> 12 hours	7	10.3
8–12 hours	15	22.1
4–7 hours	43	63.2
< 4 hours	3	4.4
Sitting posture		
Non-ergonomic	13	19.1
Ergonomic	55	80.9
Age		
≥ 40 years	50	73.5
< 40 years	18	26.5
BMI		
Obese (≥ 25)	37	54.4
Overweight (23–24.9)	12	17.6
Normal (14.5–22.9)	16	23.5
Underweight (< 18.5)	3	4.4

The demographic analysis revealed that the workforce was predominantly older, with 73.5% of participants aged ≥ 40 years, placing the majority in the higher-risk age category for developing musculoskeletal disorders. Nutritional status based on BMI also showed a concerning pattern, as more than half of the respondents (54.4%) were classified as obese, which may contribute to increased biomechanical stress on the lumbar spine.

In addition to these individual factors, work-related characteristics further illustrated potential risks. Most drivers (63.2%) reported a moderate daily sitting duration of 4–7 hours, while a smaller proportion sat for more than 12 hours per day. Sitting posture assessment demonstrated that 80.9% maintained an ergonomic posture while driving, although 19.1% reported

non-ergonomic postures that could heighten the strain on spinal structures. Collectively, these findings provided a comprehensive overview of the respondent's baseline characteristics and supported the interpretation of LBP prevalence within the study population. The relationship between the independent and dependent variables was analyzed using the Chi-Square test for the age variable and the Fisher's Exact test for sitting duration, sitting posture, and BMI. Prolonged sitting duration has the potential to increase the risk of LBP, as remaining seated for extended periods without stretching or postural changes may impose excessive pressure on the spinal structures and back muscles.

Table 2. Analysis of Independent Variables Associated with LBP

Variable	LBP		p
	Pain n (%)	No pain n (%)	
Sitting duration			
> 12 hours	4 (57.1)	3 (42.9)	0.650 ^a
8–12 hours	6 (40.0)	9 (60.0)	
4–7 hours	14 (32.6)	29 (67.4)	
< 4 hours	1 (33.3)	2 (66.7)	
Sitting posture			
Non-ergonomic	6 (46.2)	7 (53.8)	0.527 ^a
Ergonomic	19 (34.5)	36 (65.5)	
Age			
≥ 40 years	19 (38.0)	31 (62.0)	0.947 ^b
< 40 years	6 (33.3)	12 (66.7)	
BMI			
Obese (≥ 25)	12 (32.4)	25 (67.6)	0.333 ^a
Overweight (23–24.9)	3 (25.0)	9 (75.0)	
Normal (18.5–22.9)	8 (50.0)	8 (50.0)	

Underweight (< 18.5)

2 (66.7)

1 (33.3)

^a: Fisher's Exact test; ^b: Chi-Square test

Statistical analysis indicated no significant correlation between sitting duration and LBP ($p = 0.650$). Similarly, sitting posture was not significantly associated with LBP ($p = 0.527$), although a higher proportion of pain was observed in the non-ergonomic group (46.2%) compared to the ergonomic group (34.5%). Individual factors including age ($p = 0.947$) and BMI ($p = 0.333$) also failed to demonstrate statistical significance.

Statistical analysis further demonstrated that there was no significant correlation between sitting duration and LBP ($p = 0.650$), as the Fisher's Exact test demonstrated that extended sitting hours did not consistently correspond to higher pain incidence among the drivers. Although prolonged sitting was theoretically associated with increased spinal loading and muscle fatigue, this relationship was not supported by the statistical findings.

Similarly, sitting posture was not significantly associated with LBP ($p = 0.527$), despite a higher proportion of LBP cases being observed in the non-ergonomic group (46.2%) compared with the ergonomic group (34.5%). The lack of statistical significance may have been influenced by the limited number of drivers classified as having non-ergonomic sitting postures. Individual factors also showed no meaningful associations with LBP. Age did not demonstrate a significant relationship with pain occurrence ($p = 0.947$), even though lumbar elasticity and stability typically decline with increasing age. Likewise, BMI failed to show statistical significance ($p = 0.333$), despite its theoretical role in increasing mechanical load on the lower spine. Notably, the highest proportion of LBP occurred in the underweight group, though this finding was likely unreliable due to the very small sample size within that category. Collectively, these results suggested that neither occupational nor individual factors examined in this study showed statistically significant associations with LBP among Bali-Java night bus drivers.

DISCUSSION

This study examined the prevalence of LBP and its association with individual and occupational factors among night bus drivers on the Bali-Java route. The findings contribute to a broader understanding of LBP risk patterns within this specific occupational group, while also highlighting areas where empirical results diverge from established theoretical expectations.

The prevalence of LBP identified in this study (36.8%) was lower than the rates commonly reported in similar populations, which frequently ranged from 45.5% to more than 60% in studies conducted across various Asian regions.^{4,5,7} Several explanations may account for this comparatively lower prevalence. First, the healthy worker effect likely influenced the observed rate, whereby individuals experiencing severe or persistent LBP tend to exit the profession, leaving a cohort of relatively healthier and more resilient workers. Second, the widespread implementation of relay driving systems on the Bali-Java route may have provided intermittent periods of spinal unloading due to scheduled driver

rotation, thereby reducing cumulative mechanical strain. Finally, variations in symptom awareness, cultural pain reporting tendencies, and methodological differences in LBP assessment may have contributed to prevalence variation, as evidenced by studies reporting similarly lower figures of 36.6% and 34.51%.^{14,17} These findings aligned with systematic reviews indicating that LBP prevalence among drivers is highly heterogeneous and influenced by differences in exposure, population characteristics, and workload patterns.¹⁵

Individual characteristics such as age and BMI were also examined as potential contributors to LBP. However, neither variable demonstrated a statistically significant association with LBP ($p = 0.947$ for age; $p = 0.333$ for BMI). While age-related degenerative processes and elevated BMI theoretically increase mechanical loading on the lumbar spine—thereby reducing muscle elasticity, diminishing spinal stability, and elevating the risk of pain.^{11,12} The absence of a measurable association in this study may reflect the relatively homogeneous age distribution of the sample, which consisted predominantly of middle-aged drivers. Similar findings have been reported in multiple studies where age and BMI did not emerge as independent predictors of LBP, particularly when occupational exposures such as whole-body vibration (WBV) and static posture were more influential.^{15,18–20} Furthermore, the uneven distribution of BMI categories among respondents may have limited the detection of meaningful differences. These results indicated that age and BMI exerted a background physiological influence but were not decisive determinants of LBP in this population.

In contrast to the theoretical expectation that prolonged static sitting would increase LBP risk, sitting duration did not demonstrate a significant association with LBP ($p = 0.650$). Static sitting is widely recognized as an ergonomic risk factor because it increases axial pressure on intervertebral discs, reduces nutrient diffusion, accelerates disc degeneration, and elevates lumbar compression forces.^{11,13} Prior studies consistently found that sitting durations exceeding 7–8 hours were associated with higher LBP prevalence.^{12,21} The findings of this study, however, indicated that the majority of drivers fell within the “medium-duration” category (4–7 hours), which may not have exceeded biomechanical thresholds associated with pathological disc changes. It was also plausible that self-reported duration did not capture micro-breaks, posture shifts, or the quality of rest periods, which are essential for intervertebral disc rehydration and biomechanical recovery.^{14,22} Additionally, unmeasured lifestyle variables such as physical activity, exercise habits, smoking, and sleep quality (factors strongly associated with LBP risk) may have attenuated the relationship between sitting time and LBP.^{14,15,23} These findings support the argument that sitting duration alone is not a sufficiently sensitive measure of occupational spinal stress without considering complementary biomechanical and behavioral exposures.

Similarly, sitting posture did not exhibit a statistically significant association with LBP ($p = 0.527$), despite theoretical

models suggesting that non-ergonomic postures increase lumbar muscle strain, reduce blood flow to paraspinal musculature, and accelerate fatigue.^{24,25} Consistent with the theory, it was found that bus drivers exposed to non-ergonomic driving postures exhibited a greater risk of LBP than those adopting ergonomic postures.²⁶ Conversely, the non-significant finding in this study were likely due to the dynamic nature of driving, which might have explained this discrepancy, as drivers frequently adjust their posture, stretch, or reposition themselves during long trips, thereby mitigating static load accumulation. Previous research similarly emphasized that posture variability may be more protective than strict adherence to static ergonomic postures.²⁷ Furthermore, the categorical posture assessment used in this study may have lacked the sensitivity required to detect subtle biomechanical differences, whereas more advanced assessment methods such as angle-based posture analysis or pressure mapping might have produced different results.²⁸

A critical unmeasured confounder influencing both sitting duration and posture was WBV, which is widely recognized as a major determinant of LBP among professional drivers. Mechanical vibrations transmitted through the seat at frequencies resonating with the lumbar spine amplify disc compression forces and accelerate spinal microtrauma.²⁹ Numerous studies have identified WBV as a stronger predictor of LBP than posture or sitting duration, with vibration exposure modifying and potentially overshadowing the effects of static ergonomic factors.³⁰ Modern bus seats equipped with air-suspension systems reduce WBV exposure by approximately 10%, which may have mitigated the impact of non-ergonomic posture in this study.^{29,31} Thus, the lack of significant associations found in this analysis likely reflected the dominant influence of unmeasured vibration levels.

Finally, psychosocial factors, which were not examined in this study, may also have contributed to LBP risk. High job strain, workload pressure, and low social support have been shown to exacerbate pain perception and increase the incidence of musculoskeletal disorders among professional drivers.^{20,32} Chronic stress elevates paraspinal muscle tension, disrupts sleep quality, and modifies pain modulation pathways, thereby interacting with physical exposures to influence LBP outcomes.

Overall, the findings of this study suggest that while individual factors and static ergonomic exposures contributed to baseline risk, unmeasured biomechanical and psychosocial—particularly whole-body vibration, posture variability, restorative sleep, and occupational stress—likely played more dominant roles in shaping the LBP profile of night bus drivers. These results underscored the complexity of LBP etiology in occupational settings and highlighted the need for future research incorporating objective biomechanical measurements, longitudinal designs, and comprehensive assessments of lifestyle and psychosocial factors.²⁵

This study is subject to several limitations. First, the cross-sectional design precludes the establishment of causality and is susceptible to reverse causality (e.g., drivers improving their posture because they developed pain). Second, the reliance on self-reported data for LBP and driving duration introduces recall

bias. Third, the study did not objectively measure WBV or vehicle suspension quality, which are likely critical unmeasured confounders in the etiology of LBP among professional drivers.

CONCLUSION AND SUGGESTIONS

This study concludes that while low LBP affects a significant proportion (36.8%) of Bali-Java night bus drivers, there is no statistically significant correlation between sitting duration or sitting posture and the incidence of LBP in this specific population. The individual factors, such as age and BMI, also did not show a statistically significant correlation. These findings imply that LBP etiology in this group is multifactorial and likely driven by unmeasured environmental stressors—such as whole-body vibration, seat design, posture variability, driving breaks, and physical fitness level—rather than static postural factors alone.

Clinical or occupational interventions should move beyond simple postural education. Bus companies should prioritize the installation of active suspension seats to dampen whole-body vibration, which likely poses a greater risk than static posture.

Future research studies should employ longitudinal designs to establish causality. Crucially, research must incorporate objective instrumentation (such as accelerometers for vibration exposure and pressure mats for posture analysis) to build a comprehensive risk model that accounts for the dynamic reality of professional driving.

BIBLIOGRAPHY

1. Chen S, Chen M, Wu X, Lin S, Tao C, Cao H, et al. Global, Regional and National Burden of Low Back Pain 1990–2019: A Systematic Analysis of the Global Burden of Disease study 2019. *J Orthop Translat*. 2022 Jan; 32:49–58.
2. Hayden JA, Ellis J, Ogilvie R, Malmivaara A, van Tulder MW. Exercise Therapy for Chronic Low Back Pain. *Cochrane Database of Systematic Reviews*. 2021;2021(9).
3. Zhang YH, Xu HR, Yang QH, Du SH, Su X, Zheng YL, et al. Associations Between Back Pain Incidence, and Physical Activity and Sedentary Behaviors: A Prospective Cohort Study with Data from Over 365 000 Participants. *Journal of Orthopaedic & Sports Physical Therapy*. 2024 Jul;54(7):468–76.
4. Tamrin Sbm, Yokoyama K, Jalaludin J, Aziz Na, Jemoin N, Nordin R, et al. The Association between Risk Factors and Low Back Pain among Commercial Vehicle Drivers in Peninsular Malaysia: A Preliminary Result. *Ind Health*. 2007;45(2):268–78.
5. Jadhav A. Comparative Cross-Sectional Study for Understanding the Burden of Low Back Pain among Public Bus Transport Drivers. *Indian J Occup Environ Med*. 2016;20(1):26.
6. Hakim S, Mohsen A. Work-Related and Ergonomic Risk Factors Associated with Low Back Pain among

- Bus Drivers. *J Egypt Public Health Assoc.* 2017 Sep 1;92(3):195–201.
7. Amrulloh FF, Jayanti S, Wahyuni I, Widjasena B. Faktor-Faktor yang Berhubungan dengan Keluhan Nyeri Punggung Bawah pada Sopir Bus Antar Kota Antar Propinsi Po. Nusantara Trayek Kudus – Jakarta. *Jurnal Kesehatan Masyarakat.* 2017 Apr;5(2):113–20.
 8. Adi Raditya IGW, Adiartha Griadhi IP. Perbedaan Persentase Kejadian Low Back Pain (LBP) Antara Supir Bus yang Mengendarai Bus Ergonomis dan Tidak Ergonomis di Terminal Ubung dan Mengwi, Bali. *E-Jurnal Medika Udayana.* 2015 Jan;3(11).
 9. Peng BG. Pathophysiology, Diagnosis, and Treatment of Discogenic Low Back Pain. *World J Orthop.* 2013;4(2):42–52.
 10. Moore K, Dalley AF, Agur AMR. Moore's Essential Clinical Anatomy Seventh Edition. Seventh Ed. Crystal Taylor, editor. Essential clinical anatomy. Lippincott Williams & Wilkins; 2014. 289–306 p.
 11. Wijayanti F, Saftarina F. Kejadian Low Back Pain (LBP) pada Penjahit Konveksi di Kelurahan Way Halim Kota Bandar Lampung. *Medicalprofession Journal of Lampung University (MEDULA).* 2019 Feb;8(2):82–8.
 12. Pratiwi RY, Waren A, Akbar R. A Hubungan Lama Bekerja dan IMT dengan Low Back Pain pada Pengemudi Taksi X Pekanbaru. *Jambi Medical Journal (JMJJ): Jurnal Kedokteran dan Kesehatan.* 2020;8(2):135–40.
 13. Afif N, Jayanti S, Wahyuni I. Hubungan Postur Kerja, Durasi Mengemudi dengan Keluhan Nyeri Punggung Bawah (NPB) pada Sopir Truk Barang Antar Kota Di CV Semeru Putra Semarang. *Jurnal Kesehatan Masyarakat.* 2021 Jan;9(1):65–71.
 14. Nabi MH, Hawlader MDH, Naz F, Siddiquea SR, Hasan M, Hossian M, et al. Low Back Pain among Professional Bus Drivers: A Cross-Sectional Study from Bangladesh. *BMC Public Health.* 2023 Jun 19;23(1):1172.
 15. Jia J, Zhang M, Cao Z, Yang Z, Hu X, Lei S, et al. Prevalence of and Risk Factors for Low Back Pain among Professional Drivers: A Systematic Review and Meta-Analysis. *J Orthop Surg Res.* 2024 Sep 9;19(1):551.
 16. Kuorinka I, Jonsson B, Kilbom A, Vinterberg H, Biering-Sørensen F, Andersson G, et al. Standardised Nordic Questionnaires for the Analysis of Musculoskeletal Symptoms. *Appl Ergon.* 1987 Sep;18(3):233–7.
 17. Sheth A, Pagdhune A, Viramgami A. Prevalence of Work-Related Musculoskeletal Disorders (WRMSDs) and Its Association with Modifiable Risk Factors in Metropolitan Bus Transit Drivers: A Cross-Sectional Comparison. *J Family Med Prim Care.* 2023 Aug;12(8):1673–8.
 18. Portela BS, Vulczak A, Queiroga MR. Factors Associated with Low Back Pain in Workers: The Influence of Anthropometric Measures, Abdominal Endurance and Hip Flexibility. *Biomed Hum Kinet.* 2015 May 7;7(1).
 19. Hashimoto Y, Matsudaira K, Sawada SS, Gando Y, Kawakami R, Sloan RA, et al. Association Between Objectively Measured Physical Activity and Body Mass Index with Low Back Pain: A Large-Scale Cross-Sectional Study of Japanese Men. *BMC Public Health.* 2018 Dec 9;18(1):341.
 20. Chen C, Xiao B, He X, Wu J, Li W, Yan M. Prevalence of Low Back Pain in Professional Drivers: A Meta-Analysis. *Public Health.* 2024 Jun; 231:23–30.
 21. Park SM, Kim HJ, Jeong H, Kim H, Chang BS, Lee CK, et al. Longer Sitting Time and Low Physical Activity Are Closely Associated with Chronic Low Back Pain in Population Over 50 Years of Age: A Cross-Sectional Study Using the Sixth Korea National Health and Nutrition Examination Survey. *The Spine Journal.* 2018 Nov;18(11):2051–8.
 22. Balasubramanian R, Patil S, Narlawar U. Work-Related Musculoskeletal Disorders and Some Related Risk Factors among City Bus Drivers: A Cross-Sectional Study in Central India. *Indian Journal of Community Medicine.* 2025 Oct; 50(Suppl 2): S213–8.
 23. Caggiari G, Talesa GR, Toro G, Jannelli E, Monteleone G, Puddu L. What Type of Mattress Should Be Chosen to Avoid Back Pain and Improve Sleep Quality? Review Of the Literature. *Journal of Orthopaedics and Traumatology.* 2021 Dec 8;22(1):51.
 24. Tarwaka, Bakri SHA, Sudiajeng L. *Ergonomi untuk Keselamatan, Kesehatan Kerja dan Produktivitas.* 1st ed. Surakarta: UNIBA Press; 2004. 68–172 p.
 25. Andini fauzia. Risk Factors of Low Back Pain in Workers. *J Majority.* 2015 Jan;4(1):12–9.
 26. Sekaaram V, Ani LS. Prevalensi Musculoskeletal Disorders (MSDs) pada Pengemudi Angkutan Umum di Terminal Mengwi, Kabupaten Badung-Bali. *Intisari Sains Medis.* 2017 May 8;8(2):118–24.
 27. McClintock FA, Callaway AJ, Clark CJ, Alqhtani RS, Williams JM. Lumbar Sitting Behavior of Individuals with Low Back Pain: A Preliminary Study Using Extended Real-World Data. *Sensors.* 2024 Oct 21;24(20):6751.
 28. Markova V, Markov M, Petrova Z, Filkova S. Assessing the Impact of Prolonged Sitting and Poor Posture on Lower Back Pain: A Photogrammetric and Machine Learning Approach. *Computers.* 2024 Sep 14;13(9):231.
 29. Johnson PW, Hudock SD, Mcdowell T, Dalsey E. Reducing Whole Body Vibration to Improve the Safety and Health of Bus Drivers. *NIOSH Science Blog: Centers for Disease Control and Prevention.* 2016.

30. Awang Lukman K, Jeffree MS, Rampal KG. Lower Back Pain and Its Association with Whole-Body Vibration and Manual Materials Handling Among Commercial Drivers in Sabah. *International Journal of Occupational Safety and Ergonomics*. 2019 Jan 2;25(1):8–16.
31. Lantoine P, Lecocq M, Bougard C, Dousset E, Marqueste T, Bourdin C, et al. Car Seat Impact on Driver's Sitting Behavior and Perceived Discomfort During Prolonged Real Driving on Varied Road Types. *PLoS One*. 2021 Nov 16;16(11): e0259934.
32. Yang H, Lu M, Haldeman S, Swanson N. Psychosocial Risk Factors for Low Back Pain in US Workers: Data from the 2002–2018 Quality of Work Life Survey. *Am J Ind Med*. 2023 Jan 23;66(1):41–53.

