Journal of Human Centered Technology

https://www.humentech.utm.my

E-ISSN: 2821-3467

Incorporating Anthropometric Measurement and Pressure Distribution Assessment in Car Seat for Fatigue Management: An Exploratory Ergonomic Analysis

Nor Kamaliana Khamis[1,2]*, Mohd Faizal Mat Tahir[1,2], Mohd Zaki Nuawi[1,2]

[1]Department of Mechanical and Manufacturing Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, Selangor, Malaysia
[2]Centre of Automotive Research, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, Selangor, Malaysia

*Corresponding Author kamaliana@ukm.edu.my

Cite: https://doi.org/10.11113/humentech.v5n1.123

Research Article

Abstract:
An ergonomically designed driver's seat is essential for assuring quality, comfort, and safe driving. Comprehending the influence of anthropometric characteristics on seat-body contact can facilitate the development of comfort-optimized seating systems. This exploratory study examined the relationship between anthropometric dimensions and pressure distribution patterns in drivers deployed within a simulated driving environment. A pressure mapping system (Tactilus®, SPI, USA) was used to capture seat pan pressure profiles, while key anthropometric variables were recorded using an anthropometer. Eleven participants completed the driving posture protocol, and multiple regression analysis was applied to model pressure distribution outcomes. Results revealed a strong, statistically significant positive relationship between buttock-popliteal length and pre-buttock pressure (r = 0.914, p<0.01), with the regression model explaining 81.8% of the variance in pre-buttock pressure. The results emphasize buttock-popliteal length as an important indicator of localized seat pressure, underscoring the necessity for seat designs that accommodate variations in thigh length. These findings establish an ergonomic foundation for incorporating anthropometric-pressure mapping assessments into the development of proactive driver assistance systems, aimed at preventing fatigue occurrences.

Keywords: Driver; Car seat; Pressure; Fatigue; Anthropometric

1. INTRODUCTION

The increasing number of transports necessitates an understanding of drivers' physical dimensions and preferred postures, which are critical contributions of ergonomics to the vehicle design process (1). Ergonomically built seats can appeal to individuals, particularly in providing comfort during extended drives. Car seats should not induce discomfort for passengers after several hours of travel. Discomfort is associated with sensations of pain, stiffness, numbness, and cramping, often stemming from the physical limitations of seat design, or can be characterized as the unpleasant interaction between the sitter's body and its environment. Meanwhile, comfort is connected to feelings of satisfaction and well-being of the driver. Consequently, reducing the degree of discomfort experienced does not inherently elevate the amount of comfort, instead, a low level of discomfort is requisite for attaining a high level of comfort (2–4).

Driver fatigue poses a significant safety risk, since extended driving and insufficient seating lead to both physical and mental fatigue. Strategies for managing fatigue in vehicle ergonomics often emphasize enhancing posture, alleviating musculoskeletal strain, and mitigating the negative impacts of vibration exposure (5, 6). Prior research indicates that discomfort can arise within 15 to 30 minutes of sitting on inadequately developed seats (7, 8). Porter and Tait (9) found that the onset of discomfort varied based on the anatomical region and the configuration of the seats. The variation may result from drivers adjusting their posture while driving, thereby redistributing pressure to various body regions. Those changes in posture, although they may alleviate discomfort in one area, could unintentionally elevate localized pressure and strain in another, affecting overall comfort over time. Consequently, precise evaluation of driver position and its correlation with physical characteristics is crucial for formulating successful fatigue reduction strategies.

A primary approach for assessing sitting ergonomics in relation to fatigue management is the evaluation of pressure distribution at the seat–body contact. Pressure mapping facilitates the identification of elevated pressure areas that may impede blood circulation, induce tissue compression, and result in discomfort or fatigue during prolonged driving (1, 10). Prior studies have shown that interface pressure is affected by various parameters, such as cushion design, backrest angle, and individual body measurements (5, 11, 12, 13). Anthropometric measurements, especially concerning lower limb and torso proportions, are essential for comprehending individual diversity in seating interaction (13–15). Factors including buttock-popliteal length, thigh circumference, and height affect the distribution of body weight on the seat pan and backrest, thus impacting comfort and the start of fatigue. Distribution of anthropometric data with pressure distribution analysis offers a thorough assessment of seat performance, facilitating ergonomic enhancements that can directly aid fatigue

Received 10 October 2025; Accepted 26 December 2025
Available online 06 February 2026

management. Table 1 provides a synthesis of key past studies in the field of seating ergonomics, anthropometry, and fatigue management, along with their direct relevance to the present research.

Table 1. Summary of past studies on seating ergonomics, fatigue, and anthropometric assessment.

Reference	Main Aim	Main Findings	Relationship with Current Study
Li *et al*. (16)	Develop a predictive model for driver comfort by combining seat pressure distribution data with physiological measurements (e.g., heart rate variability, skin temperature).	Demonstrated that integrating biomechanical and physiological data improves accuracy of comfort prediction; pressure patterns strongly correlated with physiological indicators of discomfort and fatigue.	Supports the integration of pressure mapping with other objective measures to enhance fatigue management strategies in driver seating assessments.
Li *et al*. (6)	Analyse muscle activation patterns across different driving conditions for various Chinese anthropometric percentiles.	Identified distinct muscle activation profiles depending on driver body size and driving task; larger percentiles exhibited higher muscle loads under identical conditions.	Reinforces the importance of considering anthropometric diversity in fatigue-related ergonomic assessments, consistent with this study's focus on anthropometry–pressure distribution relationships.
Ibrahim *et al*. (17)	Investigate changes in heart rate and oxygen saturation (SpO_2) as indicators of driving fatigue.	Found that prolonged driving led to significant decreases in SpO_2 and alterations in heart rate patterns, correlating with subjective fatigue reports.	Highlights the potential for combining physiological measures with pressure distribution analysis to develop a more comprehensive fatigue assessment model for drivers.
Zhao *et al.* (18)	Monitor driver posture in highly automated vehicles using seat pressure sensors.	Successfully detected posture changes and driver activity patterns via pressure distribution data; demonstrated potential for real-time monitoring.	Directly supports the feasibility of using pressure mapping for continuous posture assessment and fatigue detection in driving contexts.
Waongenngarm *et al.* (3)	Investigate perceived musculoskeletal discomfort and postural shifts during prolonged (4-hour) sitting in office workers.	Greater discomfort reported with fewer postural shifts; frequent postural variation associated with reduced discomfort over long sitting periods.	Highlights the importance of posture variation in reducing discomfort, supporting the relevance of dynamic seating assessments alongside static pressure mapping.
Mat Tahir *et al*. (5)	Examine the relationship between drivers' dynamic pressure distribution on a car seat and their anthropometric variables under paved road conditions.	Found significant correlations between certain anthropometric parameters (e.g., weight, buttock–popliteal length) and dynamic pressure distribution patterns; heavier drivers and those with longer thighs exhibited higher peak pressures.	Directly aligns with this study's objective of linking anthropometric measures to seat pressure distribution, reinforcing the importance of thigh length and body size in ergonomic seat evaluation.
Mansfield *et al*. (4)	Integrate existing comfort models and apply them in practical ergonomic design.	Developed an integrated comfort framework combining physical, cognitive, and emotional dimensions; validated through applied case studies.	Suggests the value of linking pressure mapping (physical comfort) with other comfort dimensions for comprehensive fatigue management.
Hiemstra-van Mastrigt *et al*. (1)	Review literature to identify factors influencing passenger seat comfort and discomfort, focusing on human, context, and seat characteristics.	Found that comfort/discomfort is influenced by a combination of human factors (anthropometry, health), environmental conditions, and seat design; proposed predictive framework for seat evaluation.	Provides a theoretical basis for integrating anthropometric, seat, and contextual variables in analysing pressure distribution for fatigue management.
Vink & Hallbeck (2)	Analyse comfort and discomfort research to propose a new conceptual model for seating evaluation.	Demonstrated that comfort and discomfort are influenced by different factors and should be modelled separately; discomfort is not simply the absence of comfort.	Reinforces the need to measure pressure distribution as an independent discomfort indicator rather than assuming its inverse relationship with comfort.

https://doi.org/10.11113/humentech.v5n1.123

The table encapsulates the key objectives, principal findings, and the relevance of those findings to the present investigation for each study. This summary synthesizes insights from both foundational and contemporary research, emphasizing recurring themes such as the impact of anthropometric variability on seating comfort, the effect of posture and pressure distribution on fatigue, and the importance of quantitative assessment methods for ergonomic evaluation. The prior studies jointly establish the empirical and methodological basis for the current research, facilitating a focused examination of the relationship between certain anthropometric parameters and seat pan pressure patterns in the realm of fatigue management.

The patterns discovered in previous studies indicate a constant correlation among dimensions of the body, seating position, and interface pressure as critical factors influencing comfort and fatigue while driving. Although previous studies have highlighted the significance of seat-body interaction and anthropometric fit, there is still a necessity for comprehensive evaluations that quantitatively connect these elements into a unified predictive model, particularly in terms of pressure contact assessment. This study aims to evaluate the relationship between specific anthropometric factors and seat pan pressure distribution, with the goal of improving fatigue management strategies in vehicle ergonomics.

2. METHODOLOGY

This study utilised a cross-sectional experimental design under control laboratory experimental study to investigate the relationship between driver anthropometry and seat interface pressure distribution during a simulated driving task. Participants were instructed to adopt the same driving posture to ensure consistency in obtaining data among individuals. Prior to data collection, the driver's seat and steering wheel were adjusted once to establish a standard driving posture, ensuring comfortable pedal reach and proper hand placement on the steering wheel. The seatback rest was positioned at 100 degrees. These parameters were subsequently maintained consistently for each participant throughout the duration of the experiment. Participants were instructed to refrain from altering the seat or steering adjustments throughout the trial, and the experimenter confirmed that no modifications were made prior to each pressure measurement. The experimental technique aimed to get both objective pressure mapping data and relevant anthropometric parameters for subsequent analysis. All experiments were performed in a controlled laboratory setting, with ambient temperature maintained at around 22 to 26°C and relative humidity between 40 to 60%, ensuring thermal comfort and minimizing environmental impacts on seating posture and pressure distribution.

2.1 Equipment and Setup

A Tactilus® pressure mapping mat (Sensor Products Inc., USA) was used to measure the distribution of pressure on the car seat pan (Figure 1). The pressure mapping mat was placed on the driver seat of a fixed-base car simulator. The simulator seat is designed with dimensions and cushion geometry closely resembling a Perodua Myvi–type compact car seat. This system comprises a 22 × 22 sensor pad integrated with a 32 × 32 sensor matrix, calibrated to a range of 0 to 5 psi. The Tactilus® pressure mapping system is factory-calibrated within a measurement range of 0–5 psi. According to the manufacturer's guidelines (Sensor Products Inc.), the system does not require routine user-performed recalibration before each experiment. Instead, calibration is verified periodically through the built-in software diagnostic check, which confirms sensor stability and drift levels. The mat identifies fluctuations in electrical resistance at each grid point, enabling accurate assessment of contact pressure over the seating surface. The system was responsive to postural changes and able to measure maximum pressure, average pressure ratio, and maximum pressure gradient-parameters that are demonstrably correlated with subjective seated comfort (19). The pressure mat was affixed to the seat with masking tape to avert displacement during data gathering.

Figure 1. Tactilus® pressure mat.

Figure 2 illustrates a sample pressure distribution map obtained from the Tactilus® pressure mapping system during the driving posture assessment. The heatmap visually represents the magnitude and distribution of contact pressures across the seat pan, with warmer colours (e.g., red, orange and yellow) indicating higher localized pressures and cooler colours (e.g., blue and green) indicating lower pressures. This graphical representation allows for immediate identification of high-pressure zones, which are often associated with discomfort or potential risk of reduced blood circulation during seating (20). The pressure pattern is sensitive to changes in posture, seat adjustments, and individual anthropometric differences, making it a valuable diagnostic tool in ergonomic evaluations. By comparing maps across participants, the study can quantify variations in seat–body interaction and relate them to anthropometric measurements such as butt–popliteal length and body weight. The use of such visual data complements statistical analysis by providing a clear and intuitive understanding of how pressure is distributed on the seating surface.

https://www.humentech.utm.my
https://doi.org/10.11113/humentech.v5n1.123

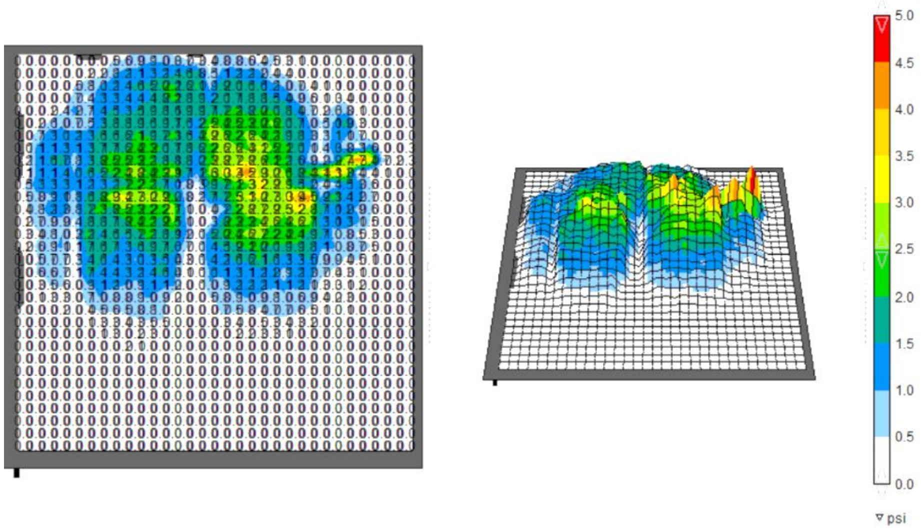

Figure 2. Example of pressure distribution map.

2.2 Procedure

Eleven participants (subjects (mean age = 28 ±4.83 years old, mean height = 161 ±6.38 cm, mean weight = 56 ±7.16 kg) This study was approved by the Ethical Committee of Universiti Kebangsaan Malaysia with code number: UKM PPI/111/8/JEP-2016-200. Participants wore lightweight clothing without bulky seams, buttons, or pockets to prevent artefacts in pressure reading. They were instructed to assume standardized driving posture feet in a semi-depressed accelerator position, hands on the steering wheel, and eyes forward while holding the posture for 30 seconds. This action was undertaken to provide adequate time for biomechanical stabilization of the body and seat interface. Thus, it is ensuring that pressure distribution measurement, such as peak pressure and gradient mapping are recorded in a consistent and reliable manner, indicative of sustained contact rather than transient fluctuations. Measurements were taken before and after a simulated driving period, each lasting approximately one minute. A length of one minute was chosen to enable the seat-body pressure signal to stabilize while reducing postural deviation. Pilot testing indicated that pressure readings generally stabilize during the initial 20–30 seconds. Thus, a one-minute interval guaranteed consistent and dependable measurements, avoiding fatigue-induced or deliberate postural modifications that could arise over extended driving periods. The dependent pressure metric for each participant was determined by averaging the pre- and post-driving data, with the pre–post difference assessed solely to verify short-term stability.

2.3 Statistical Modelling

An integrated predictive model was developed to relate anthropometric measurements to seat pressure characteristics under varying driving conditions. Prior studies use regression analysis to analyse the relationship between physiology and performance of drivers in relation to fatigue management (17). Multiple regression analysis was performed using SPSS v20 to determine the strength and significance of relationships between independent variables (anthropometric attributes) and dependent variables (seat pressure metrics). Regression coefficients (K), constants (c), multiple correlation coefficients (R), coefficients of determination (R^2), and significance levels (*p*) were calculated. Predictors with $p<0.05$ were considered statistically significant. The Ordinary Least Squares (OLS) method was used to construct the regression equation:

$$Y = K_1X_1 + K_nX_n + c \tag{1}$$

where *Y* represents the dependent variable; *X* the independent variable; *K* the regression coefficients; and *c* the constant.

3. RESULTS AND DISCUSSION

3.1 Correlation Analysis

Table 2 shows the Pearson correlation coefficients between seat pressure parameters and several anthropometric measurements. The analysis demonstrated a robust, statistically significant positive correlation between buttock–popliteal length and average buttock pressure (r = 0.914, p < 0.01), suggesting that participants with elongated thigh segments generally experienced elevated localized pressures in the buttock area during the driving task. Moderate correlations were noted between weight and thigh pressure (r = 0.588) and between height and buttock pressure (r = 0.467), however these associations did not achieve statistical significance at the 0.05 level. The significant correlation between buttock–popliteal length and buttock pressure highlights the necessity of accounting for thigh length heterogeneity in ergonomic seat design. Seat pans that are excessively short or long in relation to a driver's thigh length might result in inadequate load distribution

https://doi.org/10.11113/humentech.v5n1.123

and heightened localized pressure. Despite the small sample size (n = 11), this study was structured as an exploratory analysis of ergonomics. Significant effect sizes (e.g., r = 0.914) can be effectively identified even in limited samples, as documented in previous ergonomic pilot research (5, 10). Consequently, the correlation findings offer a preliminary indication of the association between anthropometry and seat pressure, while recognizing the necessity for larger sample sizes in future research.

Table 2. Pearson correlation coefficients between seat pressure parameters and anthropometric measurements.

		Buttock	Thigh	Butt-popliteal length	Weight	Height
Buttock	Pearson Correlation	1	-0.029	0.914**	0.199	0.467
	Sig. (2-tailed)		0.932	0.000	0.557	0.147
	N	11	11	11	11	11
Thigh	Pearson Correlation	-0.029	1	-0.125	0.588	0.327
	Sig. (2-tailed)	0.932		0.714	0.057	0.326
	N	11	11	11	11	11
Butt-popliteal length	Pearson Correlation	0.914**	-0.125	1	0.112	0.441
	Sig. (2-tailed)	0.000	0.714		0.743	0.175
	N	11	11	11	11	11
Weight	Pearson Correlation	0.199	0.588	0.112	1	0.450
	Sig. (2-tailed)	0.557	0.057	0.743		0.165
	N	11	11	11	11	11
Height	Pearson Correlation	0.467	0.327	0.441	0.450	1
	Sig. (2-tailed)	0.147	0.326	0.175	0.165	
	N	11	11	11	11	11

**Correlation is significant at the 0.01 level (2-tailed).

3.2 Regression Model

The predictive strength of this relationship was examined using regression analysis. Table 3 shows the regression analysis. The ANOVA results (Table 3(a) and 3(b)) show that the regression model was statistically significant, $F(1,9) = 45.950$, $p<0.001$, explaining 81.8% of the variance in pre-buttock pressure (Adjusted $R^2 = 0.818$). This high explanatory power indicates that buttock-popliteal length is a dominant factor influencing seat pan pressure distribution in this sample. The regression equation as shown in Equation 2 derived from the OLS method is:

$$\text{Buttock pressure} = 0.342 \times \text{Buttock-popliteal length} - 13.322 \qquad (2)$$

The model explains approximately 83.6% of the variance in pre-buttock pressure, indicating high predictive accuracy. The positive coefficient (0.342) confirms that increased thigh length directly contributes to higher pre-buttock pressure. This result suggests that seat pans should be adaptable or adjustable to accommodate varying thigh lengths among drivers, thereby reducing localized pressure hotspots and improving long-term comfort. Fixed seat pan dimensions may not sufficiently cater to anthropometric diversity, particularly in multi-user or fleet vehicles. Research demonstrates that mismatches between a driver's thigh length and fixed seat pan dimensions might result in uneven pressure distribution, indicating the advantage of adjustable seat designs to suit varying body shapes and enhance comfort (21, 22).

Table 3(a). Model summary (R Square).

Adjusted R Square	Std. Error of the Estimate
0.818	0.27926

a. Predictors: (Constant), Buttock-popliteal length

Table 3(b). Model summary (ANOVA results).

Sum of Squares	df	Mean Square	F	Sig.
3.584	1	3.584	45.95	<0.000
0.702	9	0.078		
4.285	10			

Table 4 presents the regression coefficients, showing that butt–popliteal length has a positive unstandardized coefficient (B = 0.342, $p<0.001$). This means that for each additional centimeter of thigh length, buttock pressure increases by approximately 0.342 psi. The constant term (-13.322) represents the theoretical intercept when buttock-popliteal length is zero, though this value is outside the range of practical anthropometric measurements. The standardized beta coefficient (β = 0.914) further confirms the strong effect size of thigh length on buttock pressure.

Table 4. Regression coefficients.

Model	Unstandardized Coefficients (B)	Std. Error	Standardized Coefficients (Beta)	t	Sig.
1 (Constant)	-13.322	2.392		-5.570	0.000
Buttock-popliteal length	0.342	0.050	0.914	6.779	0.000

a. Dependent Variable: Buttock

3.3 Pressure Mapping Observations

A visual inspection of pressure maps indicated individuals with longer buttock–popliteal lengths displayed greater high-pressure areas localized beneath the buttocks and proximal thighs. In contrast, participants with smaller thigh lengths had more uniformly distributed seat pan contact forces. This aligns with earlier research (10) indicating that ideal seat dimensions must reconcile thigh support with sufficient lower limb mobility. These data indicate that integrating seat pan changes may customize support to individual anthropometric profiles, thus reducing localized pressure and improving overall driving comfort.

4. CONCLUSION

This exploratory study demonstrates that buttock-popliteal length is a significant anthropometric variable affecting pressure distribution in automobile seats, particularly in the buttock area. A strong positive relationship and a promising predictive model were created, with the regression model accounting for almost 80% of pressure variability. These findings establish an empirical foundation for ergonomic seat design, specifically in creating changeable seat pan lengths to address the anthropometric variability among drivers. Subsequent research should augment the sample size, incorporate a higher proportion of female participants, and investigate the synergistic impacts of backrest angle, cushion rigidity, and dynamic driving circumstances on pressure distribution. Incorporating these ideas into seat design may result in increased driver comfort, less fatigue, and greater driving safety. Future studies should include larger samples, extended driving durations, and on-road validation to further substantiate these findings.

AUTHORSHIP CONTRIBUTION STATEMENT

Nor Kamaliana Khamis: conceptualization, methodology, project administration, supervision, data curation, formal analysis, writing – original draft, writing – review & editing. Mohd Faizal Mat Tahir: investigation, data collection, instrumentation setup, visualization, writing – review & editing. Mohd Zaki Nuawi: methodology, validation, resources, data interpretation, writing – review & editing.

DATA AVAILABILITY

Data supporting this study's findings are available upon reasonable request from the corresponding author.

DECLARATION OF COMPETING INTEREST

The authors have no conflict of interest.

DECLARATION OF GENERATIVE AI

The use of generative AI in scientific writing must be declared in a specific section of 'Declaration of Generative AI' at the end of the article. The use of AI tools to analyse and configure image diagrams is not a part of scientific writing.

ACKNOWLEDGMENT

This research was funded by Universiti Kebangsaan Malaysia and Ministry of Higher Education under FRGS/1/2023/TK10/UKM/02/3.

REFERENCES

(1) Hiemstra-van Mastrigt S, Groenesteijn L, Vink P, Kuijt-Evers LF. Predicting passenger seat comfort and discomfort on the basis of human, context and seat characteristics: a literature review. Ergonomics. 2017;60(7):889–911. https://doi.org/10.1080/00140139.2016.1233356.

(2) Vink P, Hallbeck S. Comfort and discomfort studies demonstrate the need for a new model. Appl Ergon. 2012;43(2):271–276. htpps://doi.org/10.1016/j.apergo.2011.06.001.

(3) Waongenngarm P, van der Beek AJ, Akkarakittichoke N, Janwantanakul P. Perceived musculoskeletal discomfort and its association with postural shifts during 4-h prolonged sitting in office workers. Appl Ergon. 2020;89:103225. https://doi.org/10.1016/j.apergo.2020.103225.
(4) Mansfield N, Naddeo A, Frohriep S, Vink P. Integrating and applying models of comfort. Appl Ergon. 2020;82:102917. https://doi.org/10.1016/j.apergo.2019.102917.
(5) Mat Tahir MF, Khamis NK, Wahab D, Sabri N, Hasani Z. Relationship between driver's dynamic pressure distribution with their anthropometric variables on car seat under paved road. Int J Integr Eng. 2020;12(5):55–61. https://doi.org/10.30880/ijie.2020.12.05.007.
(6) Li M, Li B, Chen G, Huading B, Shi C, Yu F. Biomechanics-based study of muscle activation under different driving conditions for Chinese percentiles. Hum Factors Ergon Manuf Serv Ind. 2024;34(6):481–490. https://doi.org/10.1002/hfm.21043.
(7) El Falou W, Duchêne J, Grabisch M, Hewson D, Langeron Y, Lino F. Evaluation of driver discomfort during long-duration car driving. Appl Ergon. 2003;34(3):249–255. https://doi.org10.1016/S0003-6870(03)00011-5.
(8) Hirao A, Kitazaki S, Yamazaki N. Development of a new driving posture focused on biomechanical loads (No. 2006-01-1302). SAE Technical Paper. 2006. https://doi.org/10.4271/2006-01-1302.
(9) Porter JM, Gyi DE, Tait HA. Interface pressure data and the prediction of driver discomfort in road trials. Appl Ergon. 2003;34(3):207–214. https://doi.org/10.1016/S0003-6870(03)00009-7.
(10) Kyung G, Nussbaum MA. Driver sitting comfort and discomfort (part II): Relationships with and prediction from interface pressure. Int J Ind Ergon. 2008;38(5-6):526–538. https://doi.org/10.1016/j.ergon.2007.08.011.
(11) Dénes L, Horváth PG, Antal RM. Comparative study of body pressure distribution on the user-cushion interfaces with various support elasticities. Int J Hum Factors Ergon. 2020;7(1):80–94. https://doi.org/1010.1504/IJHFE.2020.107293.
(12) Liu Y, Zhong X, Ghebreiyesus W, Ji J, Xi F. Analysis and modeling of human seat interaction with a focus on the upper body and backrest using biomechanics and contact mechanics. Work. 2021;68(s1): S161–S182. https://doi.org/10.3233/WOR-208015.
(13) Huang Q, Jin X, Gao M, Guo M, Sun X, Wei Y. Influence of lumbar support on tractor seat comfort based on body pressure distribution. PLoS One. 2023;18(3):e0282564. https://doi.org/10.1371/journal.pone.0282682.
(14) Zhang S, Kui H, Liu X, Zhang Z. Analysis of musculoskeletal biomechanics of lower limbs of drivers in pedal-operation states. Sensors. 2023;23(21):8897. https://doi.org/10.3390/s23218897.
(15) Wang Q, Huo Y, Xu Z, Zhang W, Shang Y, Xu H. Effects of backrest and seat-pan inclination of tractor seat on biomechanical characteristics of lumbar, abdomen, leg and spine. Comput Methods Biomech Biomed Engin. 2023;26(3):291–304. https://doi.org/10.1080/10255842.2022.2062229.
(16) Li M, Yu F, Ding B, Shi C, Wang Q, Du Y, Li H. Optimising driver comfort through pressure distribution and physiological data: a predictive model for human–machine interface design. Int J Automot Technol. 2025;1–15. https://doi.org/10.1007/s12239-025-00268-y.
(17) Ibrahim MS, Kamat SR, Shamsuddin S. An investigation of heart rate and oxygen saturation level (SpO_2) in indicating driving fatigue. Malays J Med Health Sci. 2024;20(3):1–8. https://doi.org/10.47836/mjmhs.20.3.14.
(18) Zhao M, Beurier G, Wang H, Wang X. Driver posture monitoring in highly automated vehicles using pressure measurement. Traffic Inj Prev. 2021;22(4):278–283. https://doi.org/10.1080/15389588.2021.1892087.
(19) Fiorillo I, Song Y, Vink P, Naddeo A. Designing a shaped seat-pan cushion to improve postural (dis)comfort reducing pressure distribution and increasing contact area at the interface. Proc Des Soc. 2021; 1:1113–1122. https://doi.org/10.1017/pds.2021.111.
(20) Li W, Mo R, Yu S, Chu J, Hu Y, Wang L. The effects of the seat cushion contour and the sitting posture on surface pressure distribution and comfort during seated work. Int J Occup Med Environ Health. 2020;33(5):675–689. https://doi.org/10.13075/ijomeh.1896.01582.
(21) Sabri N, Khamis NK, Ng CT, Tahir MM, Besar J. Effects of anthropometric towards interface pressure variables and design optimization on the car seat. J Kejuruteraan. 2021;33(4):969–979.
(22) Sabri N, Khamis NK, Mat Tahir MF, Besar J, Abd Wahab D. Impact of anthropometric parameters on pressure variables for determining comfort and safety of automotive seat: a systematic review. Iran J Public Health. 2022;51(2):240–249. https://doi.org/10.18502/ijph.v51i2.8678.