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The Effect of Footwear Characteristics on Driving Safety: A Mixed Method Study

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***ABSTRACT*- The diversity of footwear designs raises the question about their impact on driving safety. Studies addressing this issue are rare and there is urgent need to explore whether there is a relationship between footwear type and driving safety. The objective of this study is to answer this question by studying the effect of footwear types and some driving performance variables that have direct or indirect effect on driving safety. A mixed method approach was used consisting of experiments and questionnaire to collect the data. The results indicate that the closed shoes are safer than the open slippers while driving since they provide better control, stability and force as well as less error probability. The study recommends the decision makers to take actions for improving public awareness of the importance of proper selection of footwear for driving.**

1. INTRODUCTION

Despite the gradual reduction of their numbers worldwide, road traffic deaths and injuries remain a major global health and development challenge as evident by the estimated 1.19 million road traffic deaths in 2021 [1]. This lead The United Nations to include road safety and traffic accident prevention amongst its goals in the 2030 agenda for sustainable development [2].

Significant effort has been made to study risk factors such as the increasing number of motor vehicles, environmental factors, and personal factors [3-6]. While many of these factors that contribute to road safety are being adequately studied throughout the world, studies on the significance of footwear while driving are limited. It is believed that footwear might have impact on brake and fuel pedal misapplication, which constitutes the reason of about 0.2% of crash accidents [7]. However, rare studies explored the role of footwear in pedal misapplication despite having direct effect on foot movement, foot placement, and controlled force. Therefore, precision and controlled application of force on pedals may be impaired due to the driver's choice of footwear.

Choosing the right footwear for drivers is crucial for ensuring road safety. Given the variety of shoe options available, such as athletic shoes and sandals, there is a significant lack of comprehensive research and guidelines on the best footwear for driving. This gap in knowledge prevents individuals and regulatory bodies from making informed decisions that minimize risks and enhance driver control and responsiveness. This creates an urgent need for rigorous investigation to identify the best shoe types that optimize comfort, grip, and pedal control, thus reducing accidents caused by inappropriate footwear choices.

The objectives of this study are to study the influence of footwear types, e.g., different shoe and slipper designs, on car driving performance metrics such as degree of power, freedom, control, comfort and stability; to study the relationship between footwear types and the occurrence or potential occurrence of incidents; and to provide recommendations related to footwear types to enhance driver's performance and safety. A mixed method approach was used consisting of experiments and survey questionnaire to collect the required data, followed by statistical analysis to test the significance of the results.

2. METHODOLOGY

The current study was conducted using a mixed-approach methodology consisting of a quasi-experimental and a cross-sectional study using a questionnaire.

A. The Quasi-Experimental Study:

Four male university students aged 22-25 years were selected to implement this part of the research. Each subject was asked to drive one day wearing one of 15 footwear types (i.e., a total of 60 experiments). At the end of the day, each subject was requested to fill a diary form to evaluate his driving experience by subjectively evaluating the following factors on a 5-point Likert scale (where scores of 1, 2, 3, 4 and 5 mean very poor, poor, moderate, good and very good performance, respectively):

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(a) Intermediate performance factors:

1. The degree of applied force provided by the used footwear type. This is the amount and efficiency of pressure, force, distribution, and magnitude of force transmitted to the pedals by the foot while wearing different types of footwear.
2. The degree of freedom and flexibility provided by the used footwear type. This represent the effect of the ability of footwear to bend, twist, and adapt to various movements on the foot and ankle and the influence on the foot's natural movement and range of motion while operating the car's pedals.
3. The degree of control provided by the used footwear type. This means the effect of stability and support provided by the types of footwear on the foot while operating the car pedals which enable to safely guide the foot and offer more secure feel on the pedals to allow a better grip and fixed pressure modulation during acceleration and braking.
4. The degree of comfort associated with the used footwear type. This is the amount of pleasant and pain-free experience over a period of time while trying different types of footwear, which contributes to reducing fatigue, discomfort, and increase overall satisfaction from the footwear type level of comfort. This includes factors such as cushioning, fit, and breathability.
5. The degree of stability provided by the used footwear type. This reflects the effect of the amount of stability and support that the footwear provides on the foot balance and alignment, preventing risk of unwanted foot movement while ensuring a proper foot placement and positioning on the pedals.

(b) Outcome factor:

6. The probability of errors provided by the used footwear type. This is the likelihood of errors, mishaps, and accidents resulted by the different types of footwear such as the likelihood of slipping when operating the pedals, or probability of misuse of force on the pedals.

Fourteen types of footwear with different characteristics, as well as driving with bare foot were used in this part of the study as shown in Table 1.

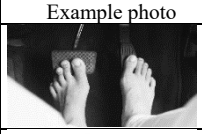
B. The Cross-Sectional Study:

This part of the research was conducted to study the views of a sample of Saudi persons on the effect of footwear on driving experience using a questionnaire methodology. The questionnaire consisted of 16 questions to collect information about:

- demographic characteristics of the participants,
- their most used footwear type and material,
- their opinions on the safety of footwear types,
- their experience with incidents related to footwear types, and
- their views on the importance of conducting awareness programs.

Only completed questionnaires were accepted by making it mandatory to answer all questions. The questionnaire was design in native language to avoid any misperception. Male and female were included in the survey. The targeted age was 18 and above. The total number of received responses was 160. The demographic data of the responders are presented in Table 2.

Table 1: Footwear types used in the quasi-experimental study

Footwear type code	Description of footwear	Example photo	Footwear type code	Description of footwear	Example photo
None	Bare foot		Type 8	Open slipper with plastic surface and 1.0-in heel	
Type 1	Flat shoe with 1.0-in sole		Type 9	Open slipper with plastic surface and 1.8-in heel	
Type 2	Curve shoe with soft surface and 1.5-in heel		Type 10	Open slipper with leather surface and 0.8-in heel	

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Type 3	Curve shoes rough surface and 1.3-in heel		Type 11	Open slipper with leather surface and 1.7-in heel	
Type 4	Running shoe with 1.5-in heel		Type 12	Narrow front shoe with leather surface and 0.9-in heel	
Type 5	Flexible running shoe with 1.7-in heel		Type 13	Narrow front shoe with leather surface and 1.5-in heel	
Type 6	Sneaker with 1.0-in heel		Type 14	Narrow front shoe with soft surface and 0.5-in heel	
Type 7	Croc with 1.3-in heel		Type 15	Narrow front curve shoe with leather surface and 2.0-in heel	

Table 2: Characteristics of the questionnaire responders

Characteristics	Value	*n*	%
Age	18-21	20	12.5
	22-30	116	72.5
	31-40	18	11.3
	Above 40	6	3.8
Gender	Male	129	80.6
	Female	31	19.4
Shoe Size	35-38	29	18.1
	39-42	59	36.9
	43-46	65	40.6
	Above 46	7	4.4
Total (*N*)		160	100

C. Statistical Analyses:

Several statistical analyses were performed using Minitab® (version 19) for various purposes as follows:

1. Reliability analysis was performed using item analysis feature in Minitab to calculate both Cronbach alpha and Pearson's coefficient. A benchmark of 0.7 for Cronbach's alpha was used for high reliability.
2. Analysis of variance (ANOVA) was performed to analyze the statistical significance of the differences among average scores given by the participants for driving safety indicators when wearing different types of footwear.
3. Hsu simultaneous tests for the significance of the differences between the mean scores given by the participants for driving safety indicators when wearing different types of footwear.
4. In all cases, a significant level of 0.05 was used.

3. RESULTS AND DISCUSSION

Table 3 presents the mean score values of various types of footwear with respect to evaluation criteria (intermediate and outcome variables). Reliability analysis shows that the Pearson's correlation coefficient among the six factors is high (0.429 – 0.858) and significant at the 0.05 level. Furthermore, the overall Cronbach's alpha was 0.92 indicating high reliability of the data collection method in the quasi-experimental part.

Table 3 shows that, on average, footwear types 1, 3-6 and 13 were the ones that achieved higher evaluation scores (> 3.0) regarding the intermediate variables (degree of power, degree of freedom, degree of control, degree of comfortable design, and degree of stability) and the outcome variable (probability of error). Footwear types 2, 9-12, 14 and 15 were given average scores from 2.2 to 2.9. Finally, types 7, 8 and the bare foot were scored less than 2. This is most

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likely because the types with the higher scores are of the closed shoe types with proper material and design for driving. On the other hand open slippers, excessively curved shoes and bare foot were found unsafe while driving experience. This is in agreement with one previous study [8]. In addition, it seems that the heel characteristics affected the driving experience of the participants, which is in agreement with [9].

Independent Variable (Type of Footwear)	Dependent Variables												Overall Mean
	Intermediate Variables										Outcome Variable		
	Degree of Power		Degree of Freedom		Degree of Control		Degree of Comfortable Design		Degree of Stability		Probability of Error		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
None	1.75	0.50	1.00	0.00	1.00	0.00	1.67	0.58	0.88	0.25	0.75	0.50	**1.2**
Type 1	3.75	0.50	4.00	0.00	3.75	0.50	3.67	0.58	3.13	1.75	2.75	1.89	**3.5**
Type 2	3.50	0.58	2.75	0.50	3.25	0.96	3.33	0.58	2.14	1.15	2.38	1.49	**2.9**
Type 3	3.75	0.50	3.00	0.00	4.00	0.82	3.67	0.58	2.38	1.25	2.75	1.89	**3.3**
Type 4	4.25	0.96	4.25	0.50	4.25	0.50	4.00	1.00	3.49	1.75	3.38	1.97	**3.9**
Type 5	4.50	0.58	4.50	0.58	4.75	0.50	4.33	0.58	3.64	2.10	3.89	2.21	**4.3**
Type 6	4.25	0.50	4.75	0.50	4.25	0.50	4.33	0.58	3.63	2.14	3.38	1.97	**4.1**
Type 7	2.25	0.50	1.75	0.50	1.75	0.50	2.00	0.00	1.38	0.75	1.38	0.75	**1.8**
Type 8	1.75	0.50	2.00	0.82	2.00	0.00	1.67	0.58	1.63	1.11	1.70	0.59	**1.8**
Type 9	2.50	1.00	3.25	0.96	2.50	1.29	3.00	0.00	2.50	1.29	2.49	1.31	**2.7**
Type 10	2.50	0.58	3.00	0.00	2.25	0.50	2.67	0.58	2.39	1.21	1.75	1.26	**2.4**
Type 11	3.75	0.50	2.50	0.58	3.00	0.82	3.67	0.58	2.13	1.18	2.39	1.46	**2.9**
Type 12	2.75	0.50	2.25	0.50	2.00	1.15	2.67	0.58	1.88	1.03	1.38	1.11	**2.2**
Type 13	3.50	0.58	2.75	1.26	4.00	0.00	3.33	0.58	2.64	1.46	3.31	1.37	**3.3**
Type 14	3.00	0.82	2.25	0.50	2.00	1.41	3.00	1.00	1.95	0.89	1.13	0.63	**2.2**
Type 15	2.75	0.50	2.25	0.50	2.00	1.15	2.67	0.58	1.88	1.03	1.38	1.11	**2.2**

According to Hsu test for the significance of the differences between the mean scores, it was found that footwear types 4-6 showed very close performance in all the driving experience variables. However, in some variables footwear types 1, 3 and 13 achieved the same high performance. In all cases, ANOVA analysis revealed significant relationships (*P*-value = 0.000) between footwear type and the six (intermediate and outcome) variables.
In line with the quai-experimental study, the questionnaire results revealed that the majority of the participants believed that the close shoes provide better control and force as shown in Figure 1.

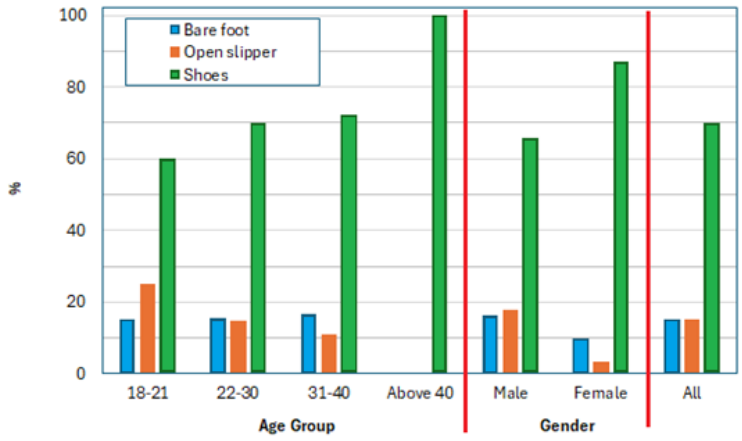

Figure 1: Responses of the participants on which footwear type provides the best force and control

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In addition, the participants reported that their experience of driving incidents due to open slippers was more than with closed shoes as shown in Figure 2.

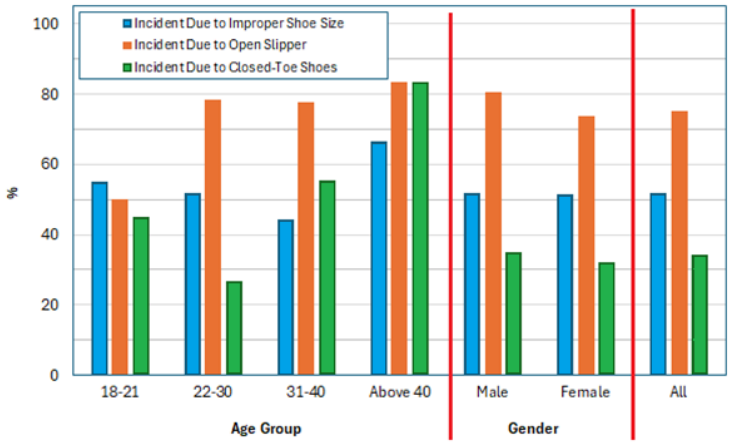

Figure 2: The experienced incidents that are related to footwear type among the participants

4. CONCLUSION

In the current research, both the experimental study and the survey questionnaire conclude that the type of footwear has significant impact on the driving experience and, hence, on the driving safety. Generally, the fully closed footwear types provide better experience than the open slippers and the shoes with abnormal design, such as excessive curvature, very low or very high heel.

It is recommended that awareness programs on the factors affected by different footwear to be designed and implemented to improve the drivers' selection of the appropriate footwear to achieve a safe driving experience. By providing drivers with scientifically supported guidelines, individuals can make informed choices that align with the principles of safety and control. Simultaneously, regulatory bodies can develop and implement policies that promote the adoption of appropriate driving footwear, thereby reducing the occurrence of accidents and improving overall road safety outcomes.

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