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Ergonomic Perspective: Mismatch between Seat Drivers and Anthropometric Measures of Elderly Taxi Drivers in Malaysia

Irwan Syah Md Yusoff [1*], Shamsul Bahri Mohd Tamrin [2], Muhammad Heikal Ismail[3]

[1]Department of Resource Management and Consumer Studies, Faculty of Human Ecology, Universiti Putra Malaysia, Serdang. 40300, MALAYSIA

[1]Malaysian Research Institute on Ageing, Universiti Putra Malaysia, Serdang. 40300, MALAYSIA

[2]Department of Environmental and Occupational Health, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, Serdang. 40300, MALAYSIA

[3]Department of Chemical and Environmental Engineering, Faculty of Engineering, Universiti Putra Malaysia, Serdang. 40300, MALAYSIA

*Corresponding Author

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Abstract: The ageing community may keep resuming their service even after the pension, which was influenced by their previous work environment. One of the occupations that elderly individuals could engage in is taxi drivers. Feelings of discomfort are generated among drivers when there is a mismatch between the product/device and the user. This study's principal objective is to assess the mismatch between seat drivers and anthropometric measurements among elderly taxi drivers to improve their work environment in term of safety and health. A cross-sectional study was led utilizing a self-administered survey instrument that involved four taxi cars from Proton products on seat measurement. Secondary data applied to obtain anthropometric measurements of elderly taxi drivers, which involved 56 elderly (male) drivers. The anthropometric parameters and seat parameters measured. The mismatch can be determined at any value over 95% or less than 80% of the respondents' total number. The measurements between 80% to 99% are classified as matched to the reference value of the respondents. The cushion width based on the proposed size at 95th percentiles show as much as 91.8% is matched to the width of the hip of the elderly taxi drivers. The backrest width which refers to the proposed measurement at 95th percentiles matched 94.0% the length of elderly taxi drivers' shoulder. The proposed cushion length measurement with knee-length to the buttock of elderly taxi drivers at a 5th percentile is 92.8% matched. The study provides a concrete foundation to identify a mismatch between current seat size with anthropometric of elderly taxi drivers that cause injury or pain due to discomfort while driving in Malaysia. It also helps us initiate the prevention of musculoskeletal disorders (MSDs) in health and safety. The baseline data is believed to benefit the automotive industry before the designing process.

Keywords: Anthropometric, elderly, taxi driver, mismatch, ergonomics, Malaysia

*Corresponding author: irwansyah@upm.edu.my

1. Introduction

In particular, the motoring industry has neglected the problems among drivers as a whole, with no emphasis on car design. Therefore, it is deemed to be inappropriate for drivers with age-related problems [1]. According to Smith et al. (1993), transportation is a crucial indicator of the quality of life and well-being among the elderly and critical access to private cars. Therefore, since the year 2000, transportation has become essential to everyone and not anyone relevant to measure the level of life. Transportation is the key to the quality of life and ensures well-being among the elderly and communication between one destination and a destination for all communities [2].

In this regard, the taxi driver is a professional occupation for drivers such as bus, train, tractor, and forklift. In Peninsular Malaysia, there were 60,472 taxi drivers, which is 59,174 (98%) male taxi drivers, while only 1,298 (2%) female taxi drivers [3]. There is an estimated 10% of taxi drivers are elderly taxi drivers. It is predicted that this value would increase, and the taxi drivers' population under the old category is expected to increase. Indeed, the design of car seats and seating arrangements play an important role in the suitability of human body, in particular to consumers' health.

Ergonomics is one of the essential factors that need to be emphasized during vehicle seat development. The most critical factors that emphasized ergonomic applications in vehicle design development are information on the size of the user's anthropometric measurements (male/female) and posture position [4]. Comfortable and secure driver's seats play a significant role in designing and fabricating vehicles. The driver comfort is just as important as the design on the vehicle's function and aesthetic value with elderly taxi drivers with the priority on safety features and comfort while driving [5,6]. The latest information and data related to comfort and convenience are minimal. Meanwhile, the need for knowledge related to comfort and safety is indispensable as the use of comfort and safety-related products occurs very frequently [7]. The driver's seat's level of comfort and safety is to identify and determine the parameters that affect the level of comfort and safety of drivers [8,9].

Based on previous studies, one factor contributing to fatigue and low back pain drivers is vehicle seat design and inappropriate human body size measurements [10]. According to Deros et al. (2015), to obtain driving comfort, the user (male/female) needs a chair design that fits the size of its body posture size. Feelings of discomfort are generated among drivers when there is a mismatch between the product/device and the user. Accordingly, an ergonomic approach should be implemented to ensure driver's comfort and minimize musculoskeletal disorders (MSDs), especially on the lower and upper limbs [6,9,11,12]. Therefore, this study's principal objective is to assess the mismatch between seat drivers and anthropometric measurements among elderly taxi drivers to improve their working environment concerning safety and health. According to the authors' best knowledge, this is the first study done in Malaysia's context to assess this problem.

2. Methods

The cross-sectional study investigates seat discomfort characteristics due to the seating posture among older taxi drivers in Peninsular Malaysia. The survey was conducted around the rural and urban areas in four regions of Malaysia which is 443 taxi cars from Proton products involved in 4 variants model (Iswara, Waja, Wira, Saga). The purposive sampling technique was chosen, and the primary inclusion criteria that have been used to select the samples were: above 60 years of age, having a minimum 1-year experience in taxi driving and having SPAD registration. The “Budget Car” and “Hired Car” taxi drivers were only selected for the study, and they were chosen according to the higher distribution number of taxi licenses and characteristics of the car itself. The car seats should be in standard seat design, and no modification was involved. Each survey took approximately 10-15 minutes to complete. The respondents were kindly asked to obtain a small token of appreciation if they successfully took part in the survey.

2.1 Mismatch Calculation

The mismatch value can be determined at any value over 95% or less than 80% of the total number of respondents [13]. Accurate result of the mismatch definition more clearly, a measurement value of more than 99% or less than 80% of the total study respondents' references are classified as a mismatch [13]. While any value less than 80% is a mismatch at a high level, any value above 99% is defined as a mismatch at a low level of respondents' total reference. Therefore, the measurements between 80% to 99% are classified according to the respondents' reference value.

Table 1 - A summary of methods & valuation of mismatch study

Mismatch Rating [13]	
High Mismatch	**<80%** from the reference number of respondents
Low Mismatch	**>99%** from the reference number of respondents
Corresponding	**80% > 99%** from the reference number of respondents
Anthropometric & product(number of respondents as reference)	**95%** of the total population of the respondents
95%til	Width of Backrest **VS** Breath of Shoulder
	Width of Cushion **VS** Breath of Hip
5%til	Height of Backrest **VS** Height of Sitting Shoulder
	Length of Cushion **VS** Length of Buttock to Knee

2.2 Anthropometric Measurement

Secondary data applied to obtain anthropometric measurements of elderly taxi drivers. Secondary data referenced based on a previous study entitled "The relationship between anthropometry and hand grip strength among elderly Malaysians,"[14]. The anthropometric data measured are based on MS ISO 7250 standards [15]. A total of 38 parameters were measured in the previous study, which involved 56 elderly (male) respondents. However, only seven parameters of anthropometric measurement were involved in this study. Among the parameters measured were: 1) height, 2) sitting height, 3) popliteal height, 4) shoulder breath, 5) hip breadth, 6) sitting shoulder height, and 7) length of the buttock to the knee (Figure 1).

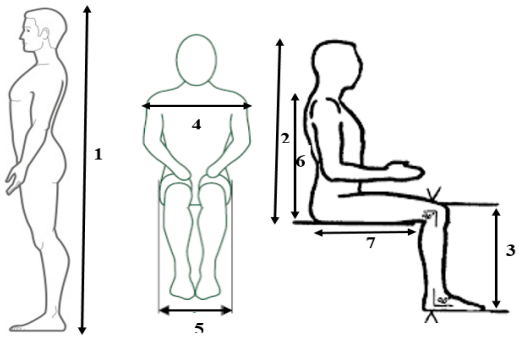

Fig. 1 - Anthropometric variables

2.3 Seat Measurement

There are four taxi cars models from Proton products involved in this study 1) Iswara, 2) Saga, 3) Wira, 4) Waja and economy/basic model. The car seats for the four model came from the same manufacturer and used the same dimension. The seat size of the taxi driver from each taxi model involved was measured accordingly. The seat for four car model criteria was chosen as follows: 1) seat origin from manufacture and not modify, 2) car less than five years from the date of manufacture, 3) economy/basic model. The selected parameters were based on previous studies related to seat measurements' comfort level with the anthropometric measurements of car drivers in Malaysia [16]. Figure 2 shows an example of a measurement process, and Table 1 shows process mismatch calculation with selective anthropometry measurement and product dimension.

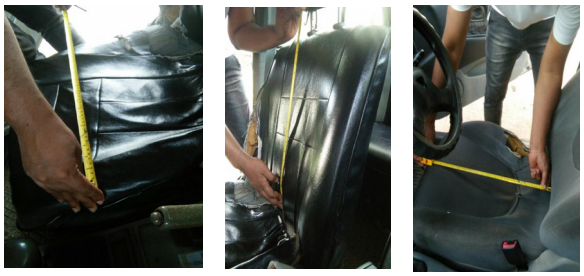

Fig. 2 -The procedure of measuring seat dimension

3. Result

Table 2 shows the comfort analysis results on the seat design among 442 elderly taxi drivers involved in this study. Respondents using the Iswara model are the highest (52.8%), the Saga model is the second-highest (21.9%), followed by the Wira model (17.8%) and Waja model (7.4%). To determine the comfort of seat design features, 61.2% of respondents recorded minor discomfort in the cushion width, 60.3% length of the cushion and 53.3% width of the backrest of the driver's seat. However, for the backrest height, 44.9% of respondents stated discomfort and 40.0% less discomfort. There are several results that showed the highest score of discomforts, such as the height of backrest (44.9%), overall seat drivers (46.0%), design (52.1%) and quality of material (49.2%).

Table 2 - Taxi model distribution and characteristic comfort level of seat

Factors	**N**		**Percentage (%)**		
Taxi Model					
Iswara	234.0		52.8		
Saga	97.0		21.9		
Waja	33.0		7.4		
Wira	79.0		17.8		
Comfort level seat design elderly taxi drivers					
	N (%)				
	Very discomfort	**Discomfort**	**Less discomfort**	**Comfort**	**Very comfort**
Width of cushion	3.0(0.7)	116.0(26.2)	271.0(61.2)	49.0(11.1)	4.0(0.9)
Length of cushion	3.0(0.7)	120.0(27.1)	267.0(60.3)	49.0(11.1)	4.0(0.9)
Width of backrest	4.0(0.9)	155.0(35.0)	236.0(53.3)	44.0(9.9)	4.0(0.9)
Height of backrest	2.0(0.5)	199.0(44.9)	177.0(40.0)	63.0(14.2)	2.0(0.5)
Overall seat drivers	11.0(2.5)	204.0(46.0)	177.0(40.0)	49.0(11.1)	2.0(0.5)
Design	23.0(5.2)	231.0(52.1)	160.0(36.1)	27.0(6.1)	2.0(0.5)
Quality of material	21.0(4.7)	218.0(49.2)	162.0(36.6)	40.0(9.0)	2.0(0.5)

N = 443

3.1 Elderly Taxi Driver Seat Specifications

The Measurement of mismatches of elderly taxi driver seats with anthropometric measures to propose new measures appropriate for elderly taxi drivers. Table 3 shows the mean backrest height measurements are 57.25 ± 4.70 cm, and the 5th and 95th measurements are 52.50 cm and 63.00 cm. Meanwhile, the average Measurement of the backrest width is 49.25 ± 1.10 cm and the 5th - 47.50 cm and 95th - 51.25 cm measurements. Based on the analysis, the average cushion length is 50.83 ± 0.50 cm, and the 5th and 95th dimensions are 50.00 cm and 51.50 cm. The average cushion width is 50.83 ± 0.53 cm and the 5th - 50.00 cm, and 95th - 51.50 cm.

Table 3 - Seat dimension with users

Dimension	**Mean ± (S.D)**	**Percentiles :5th**	**Percentiles :95th**
Height of Backrest	57.25±4.70	52.50	63.00
Width of Backrest	49.25±1.10	47.50	51.25
Length of Cushion	50.83±0.50	50.00	51.50
Width of Cushion	50.83±0.53	50.00	51.50

*Value in centimetre (cm)

3.2 Anthropometric Dimension

The analysis results for anthropometric data are obtained from the secondary data measurements of the Malaysian male population aged 60 years and above, as shown in Table 4. The average height is 161.10 ± 5.00 cm. The height measurements for 5th and 95th are 152.90 cm and 168.5 cm. The sitting position's average height was 82.10 ± 3.90 cm, and the size of 5thl and 95th was 74.60 cm and 86.50 cm. Therefore, the average popliteal height in the sitting position is 40.80 ± 3.20, as well as 5th - 35.50 cm and 90th - 45.30 cm. The shoulder width is averaged at 39.30 ± 3.60 cm and 5th - 34.20 cm, and 90th - 45.30 cm. The average size of hip width is 34.50 ± 3.70 cm, and the size of 5th - 28.80 cm and 95th - 40.50 cm. Meanwhile, the sitting position's average shoulder height is 55.00 ± 3.30 cm and measures at 5th - 49.40 cm and 95th - 59.90 cm. The average size of the knee to back length is 45.50 ± 2.70 cm, and the size of 5th, 50th and 95th is 41.50 cm, 45.50 cm and 50.50 cm.

Table 4 - 60 years and above Malaysian male population anthropometric dimension [14]

Dimension	Mean ± (S.D)	Percentiles :5th	Percentiles :95th
Stature	161.10±5.0	152.09	168.5
Height of Sitting	82.10±3.90	74.60	86.50
Height of Popliteal	40.80±3.20	35.50	45.30
Breath of Shoulder	39.30±3.60	34.20	45.30
Breath of Hip	34.50±3.70	28.80	40.50
Height of Sitting Shoulder	55.00±3.30	49.40	59.90
Length of Buttock to Knee	45.50±2.70	41.50	50.50

N =56

3.3 Mismatch and Recommendation Dimension

Table 5 shows there is a mismatch between backrest height with shoulder height (96.2%), backrest width with shoulder width (95.3%), length of the cushion with the length of the knee to the back (91.9%) and the cushion width with the width of the thigh (91.0%). The proportion of seat size with respondents is low at 3.8%, 4.7%, 8.1% and 9.0% when measuring the fit between the size of the seat and anthropometric measure of elderly taxi drivers.

Table 5 - Mismatch dimension with seat variables and anthropometric measurement

Parameter	Percentiles	Dimension (cm)	Matched (%)
Width of cushion with breath of hip	100	51.50	9.0
Width of backrest with breath of shoulder	100	51.25	4.7
Length of cushion with length of buttock to knee	100	50.00	8.1
Height of backrest with height of sitting shoulder	100	52.50	3.8

*Value in centimetre (cm)

3.4 Proposed Dimension and Comparison Dimensions

All proposed measures refer to 95th and 5th percentiles of elderly taxi drivers. For the cushion size, the width is 40.50 cm, and the backrest width is 45.30 cm. Meanwhile, the recommended measure for cushion length is 41.50 cm, and the backrest height is 49.40 cm. Table 5 compares the size of a conventional taxi seat size with the new proposed dimension. The cushion width based on the proposed size at 95th percentiles with the width of the hip of elderly taxi drivers shows as much as 91.8% is matched. Therefore, backrest width refers to the proposed measure at 95th percentiles with shoulder length of elderly taxi drivers are as much as 94.0% matching. The proposed cushion length measurement with knee-length to the buttock of elderly taxi drivers at a 5th percentile is 92.8% matched, and the rest is mismatched. Meanwhile, the backrest height based on the proposed measurement at 5th percentiles with shoulder height at sitting position elderly taxi drivers is 95.0% matched.

Table 6 - Comparison between mismatch dimensions and new proposed dimensions

Parameter	Percentiles		Proposed dimension		Matched (%)	
	Current	Percentage	Current	New dimensions	Current	New dimensions
Width of cushion	100	95	51.50	40.50	9.0	91.8
Width of backrest	100	95	51.25	45.30	4.7	94.0
Length of cushion	100	5	50.00	41.50	8.1	92.8

Height of backrest	100	5	52.50	49.40	3.8	95.0

*Value in centimetre (cm)

4. Discussion

The first national car (Proton) model used for taxi services widely in Malaysia is the first edition of the Proton Iswara model in the 1990s and 2000s. Thus, the study showed that 52.8% of respondents had chosen the Proton Saga Iswara model and 21.9% for the second edition of Proton Saga. This model has high demand among elderly taxi drivers because the selling price in the market is lower than other Proton model variations, easy to maintain, more economical and same supplier seats for all economic variation of Proton models.

Safe and seat comfort plays a vital role in car design and fabrication [11,16]. Meanwhile, the seated driver should be based on the anthropometric measurement of the population referred to increase the level of comfort and safety of the driver himself [17]. Therefore, the result showed 61.2% width of the cushion, length of the cushion (60.3%) and 53.3% backrest of the driver's seat that they were less comfortable. Meanwhile, the highest values that answered uncomfortably were the design of seat drivers (52.1%), quality of material (49.2%), overall seating size (46.0%) and backrest support (44.9%). It was proven that mismatch factors have affected the health in particular to MSDs problems and influence the drivers' comfort level [6,9,11,16,18].

The anthropometric values are usually taken between the 5th and 95th percentiles [13-14]. Both 5th and 95th percentiles were used to ensure that the proposed measurements meet 95% of the total study population. The proposed measure for backrest height has met the 95% matching value. Followed by backrest width by 94.0% matching and cushion length is 92.8% matching, and cushion width is 91.8% matching by representing 95% of the study population. Based on the size of the study proposal, there is a difference with the previous opinion that the height of the backrest is 41.70 cm compared to the study proposal (49.40 cm), the width of the backrest is 48.00 cm compared to the study findings of 45.30 cm, the length of the cushion is 38.14 cm compared to the value of the study proposal is 41.50 cm and cushion width of 50.30 cm compared to the proposed value of 40.50 cm [14]. However, this difference not only occurs in the study [16], but other studies also show similar differences by referring to the parameters used to be deemed parallel. Differences in values occur due to differences in age, population, geography, socio-demographics and ethnicity. In general, when there is an increase in age, it will cause muscle tissue to relax and shrink, and the body's posture structure decreases. Previous studies have stated the differences in anthropometric data between ethnic groups, and there may also be differences in a population [19-21]. Differences in parameter values for driver seats also occur between Malaysia's anthropometric data from the previous study [16,19-23]. However, this study only involves the elderly who are older than 60 years and above, and the total number of study respondents involved for anthropometric measurement is only 56 respondents obtained from secondary data [14].

A study on anthropometric data collection specifically for the elderly involving many respondents has not been conducted previously. However, an anthropometric data study involving the elderly in Malaysia entitled "An Elderly Friendly Housing Environment for Older Malaysians" with 129 male and 101 female respondents in 2003 was conducted by the Institute of Gerontology, Universiti Putra Malaysia. This data cannot be applied because of the significant difference in the distance of the year (15 years) from the year this study was done, and it is feared that there will be changes in the respondents' population size and character.

5. Conclusion

In conclusion, this study provides a concrete foundation to identify a mismatched current seat size with anthropometric elderly taxi drivers that cause injury or pain due to discomfort while driving in Malaysia. It also helps to initiate the prevention of MSDs in terms of health and safety. The baseline data also benefit the automotive industry during the design process. However, further research is required to investigate other perspectives such as materials, testing, design and other elements.

Regarding technological changes that create e-hailing services compared to conventional methods and the existence of e-hailing service companies enforced by the Malaysian government that use mobile applications such as Grab and My Car has made the more comprehensive data collection process challenging to perform as these services operated by private sectors. Therefore, all parties' involvement is needed to produce a measure of compatibility to ensure the comfort and safety of taxi drivers, specifically among the elderly, as well as to increase productivity and well-being [24]. This will facilitate taxi drivers, specifically the elderly, to improve their quality of life, particularly their safety and health. Indeed, the Ergonomics Intervention Approach reduces MSD-related problems that give us some practical foundation for further research.

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