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"DRIVER ERGONOMICS INVESTIGATION IN SMALL CAR SEGMENTS BY CROSS-TABULATION METHODS"

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ABSTRACT

In this paper main focus on the comfort of the car drivers' posture. As gathered from previous literature, fatigue is always associated with long duration of driving. Fatigue resulting from long-term driving can affect driver performance and are classified into physical and mental fatigue. Driving postural angles were taken from three different cars with two different companies. The cars chosen are from compact and entry midsize segment cars. These cars represent the highest, average and the lowest ranks of cars used. Data management and analysis was performed using SPSS tool. Statistical analysis involves a collection of methods used to evaluate large bulk of data and report the general trends obtained with highest scores. This study has explained the central importance of incorporating comfort in driver's car seat design. The results show that participants move significantly more in the static configuration and that they perceive more discomfort. The seat's comfort and support are evaluated significantly better in the dynamic configuration. Further research should investigate the effects in the context of driving on the road and an actual driving task.

Keyword: *Driving posture, driver performance, SPSS tool, car seat design, discomfor*

I. INTRODUCTION

As early as 18th century doctors noted that workers who required to maintain body positions for long periods of time developed musculoskeletal problems. Within last 20 years research has clearly established connections between certain job tasks and RSI or MSD. The year 1857 falls in the fourth year of the Ansei period in Japan, which was the time just after the arrival of Perry and his black ships. Association between "labor" and "health", in other words, the kinds of "health problems" caused by "working" was often reported even in the age of ancient Egypt and the Greek and Roman period. It is in "De morbis artificum diatribe," a classic by Bernardino Ramazzini (1633-1714), an Italian physician, that the relationship between working conditions and pathology was first systematized from an occupational health perspective. In order to optimize the different parameters which could reduce the injuries related to seat back and head rest and suggested that seat of driver should be ergonomically designed according to the contours of human body and head restraint so that it could provide necessary support to head & neck and leads to decreases the chance of injury. Niel Manfield et.al [1] – highlighted the effect of changing road condition and seat foam composition on driver discomfort in vehicle seats. Authors find that after 40 minutes there is discomfort in both the seat but the difference was insignificant and suggested for long duration dynamic testing while developing vehicle seats.Marry E Mossey et.al [2]- explored the driver interactions with steering wheels in four vehicles by using anthropometric data, driver hand placement and driver grip design preference. The study was completed by the formation of two groups of participant

one age between 47 to 69 years and other 18 to 29 years. There demographic data were collected and with the help of t test authors recommended for work in steering wheel grip design and naturalistic driver hand positioning are also discussed. Vignesh T. Shekar et.al [3] - established a set of guidelines exclusively for designing bus and coach driver workspace. Discussed about the various systems in the drivers workspace and their relevance to drivers ergonomics. Besides studying the driver's reachability of controls and other ergonomics aspects the authors emphasised on understanding the factors influencing driver's field of vision. Kedar Chimote et.al [4] - recommended best possible alternatives of driver's seat with the aid of ergonomics and advanced design tools like CAD,CAE . A survey was conducted amongst the truck drivers to examine the travel time factors & seat discomforts and leads to the conclusion that it is important to design the comfortable seat for truck drivers keeping in the view the ergonomic factors such as anthropometry, physiological work load, physiological stress etc. Mike Kolich et.al [5] - proposed the application of an analytical technique common to engineering circle called Design Failure Mode and Effect Analysis (DFMA) and demonstrated DFMA could have a valuable role to play in seating comfort development and ergonomics by supplying strong evidence for the advantages of particular design alternatives.

Rahul Shaik et.al [6] - concluded that increasing age, work experience, maximum working hours per week, increased left shoulder to handle distance and greater driver seat vibrations are increasing the risk of MSD and restricted lower cabin space and reduced shoulder to handle distance on right side also increasing the risk of musculoskeletal disorder. Onawumi et.al [7] - studied involved the PEIA, PIE survey and analysis of workplace which were used in the evaluation of ergonomic suitability of driver. They proposed for legislative instruments which were control frivolous importation of vehicles that do not meet ergonomic standard. Also stated that government should establish an ergonomic department in the Ministry of Productivity whose responsibility for development of reliable database for different categories of user population in the country and also suggested to the manufacturer of products where vehicle are imported from should be properly informed and mandated to produce to specifications arrived at using the Nigerian anthropometric database. Begum Nurun Nahar et.al [8] - performed a survey on professional taxi driver with help of questionnaire. The study demonstrated that 78% of car drivers reported lower back pain for at least one day during past 12 months. Their study also revealed the effect of age, daily and cumulative driving in drivers and stature become a cause of risk factors of lower back pain. Somnath Gangopadhyay et.al [9] - performed an ergonomics study on the musculoskeletal disorder among Indian bus conductor. A questionnaire based on modified Nordic Musculoskeletal questionnaire (NMQ), assessment of physical and physiological parameters, analysis of working posture and a detailed work study were performed. The authors reported that MSD mainly affecting leg, knee, shoulder and back areas and increases day by day and stated that bus conductor were continuously standing for long period and their serve workload may result in the development of MSD. Kishor Powar et.al [10] - designed a truck cabin for improved ergonomics and comfort for driver in Indian driving condition and the main attention was kept on the psychological and behavioural pattern of Indian driver along with the ergonomics issues. In the end researchers introduced new modern style of interior design with simple straight line composition and a combination of dark and light colours and all the ergonomics consideration were included in design and validated by software analysis. Sam Brook et.al [11] -Developed an ergonomic data measurement system that integrates five subsystems – an electrogoniometery system, a pressure pads, an electromyography system, the vehicle on board diagnostic system, a GPS system and audio visual system. With the help of questionnaire to evaluate subjective comfort during test drive and verbal feedback from the driver was collected throughout the driving event. The results showed that first two drivers operates the accelerator pedal mainly in plantraflexion around the midpoint of MVC range while the other driver operated the accelerator pedal in the middle of the dorsiflexion range which could explain higher level of discomfort. The author concluded that with help of integrated measurement.

II. DRIVING DISCOMFORTS AND THEIR ASSOCIATED CAUSES

- **Driving Statistics-**

A recent survey from Loughborough University in the UK linked long hours behind the wheel to:

- back pain;
- greater risk for low back trouble than sitting and standing jobs/activities;
- Increased frequency of discomforts with the number of miles driven annually.

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- **Drivers' Health-**
  - Prolonged exposure to driving cars has been identified as a risk factor for low back pain and other WMSDs.
  - Those who drive for 20 hours per week or more are at an increased risk for WMSDs.
  - Driving forces the driver to sit in a constrained posture.

II. RESEARCH METHODOLOGY

It has been identified from the literature that there are specific issues related to the seating comfort of drivers, which are, physical. Part of the focus of this research is to understand the seating ergonomics of drivers.

A questionnaire survey was therefore conducted to build on the literature and further address the following objective:

• To identify key issues with the driving experiences.

- Research method
- Survey design and rationale

The survey was used to obtain background information about participants, including: age; gender; make/model of their vehicle; annual mileage and average hours driven in a typical week and whether they drive as part of their job. Their name and date of birth is not reported for reasons of keeping anonymity.

Respondents were also asked about in-vehicle tasks specific to driving including operating pedals; signals and lights; mirrors and hand brake and on non-driving tasks including climate controls and entertainment devices such as operating the radio. It was important to have a section based on in-vehicle tasks because these are the primary tasks that the user is involved in their vehicle.

It was identified in the literature review that there was a gap in the research on the postures that older drivers adopt and seat design focusing on the requirements of this age group. A section of the survey focused specifically on the adjustability of the seat features and how users interact with them to set their driving positions. Also the literature review in Chapter 2 revealed that many people experience physical limitations such as arthritis, and upper body flexibility which may impact on reach to the seat belt; pulling it across their body and fastening it. Similarly, with adjusting the head rest a lot of physical effort may be required turning the head and body around. Specific controls such as the seat lifter and seat recline can also be stiff and difficult to turn or grasp for a person with arthritis. Therefore it was important to include a section focusing on seat features.

Research was carried out on previous questionnaires relevant to the topic, these were checked and analysed in their structure and content. Elements from a survey conducted by Sang et al. (2009) were included into the survey with slight changes; this includes a simplified version of NMQ, and specific questions. Incorporating relevant questions from other questionnaires brings many advantages, for example:

• Questions are already piloted and tested for their reliability

• The results can be compared between both studies

The final questionnaire went through various stages during the design and development phase. Many factors were considered, e.g. questions had to be specific, short and easy to understand for older people. Rather than creating long questions, Likert scales were incorporated with specific statements and tick boxes. Comment sections were also included at the end of each section for participants to add extra comments. Generally some people do not want to give their personal details such as name, date of birth etc. These types of questions were excluded from the survey for

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example; tick boxes were used to indicate their age range (20-34, 35-49, 50-64). However there was an option for participants to give their contact details for follow-up interviews or for clarification of any points.

3.2 Pilot study

A pilot study was conducted on the questionnaire survey; online and paper based versions focusing on the following points:

- To check the wording and structure of the questionnaire.
- To ensure that the responses were as anticipated.
- To capture the time taken to complete the survey.
- To develop a strategy for data analysis using SPSS.

3.2.1 Participants

A convenience sample of drivers was obtained. This involves participants that are easy to find or available for the study (Owen 1998). It is a simple and quick method, commonly used in pilot studies. A total number of 77 participants took part in the pilot study .

3.2.2 Key points

Small typographical modifications were made to some of the questions to improve clarity. Other specific changes include:

- For the questions on mileage and weekly car usage in the section on 'about the vehicle you drive', structured options were included for participants to select from.
- On the question regarding current work status in the section on 'background information' more options were provided to accommodate different backgrounds.

• Some participants felt that they needed to provide further detail on the problems they experienced; therefore a 'comments' section was included at the end of each section in the survey.

The pilot study showed that the responses were as anticipated. The average time taken to complete a questionnaire was 10 minutes (range 6-16 minutes). A copy of the final questionnaire can be found in Appendix 1

The participants and parameters of study procedure for data measurement process and the statistical analysis are described in detailed. Participants: The numbers of participants involved in this experiment was 77 Ujjain citizens (areas of ujjain east and west) which comprise of 20 females and 57 males. The participants' age ranged from 20-60 years old. Minimum driving experience is one year to ensure the drivers have adequate experience in driving. As a token, the participants were given some incentives for their contribution

3.2.3 Parameters

The measured dimensions for this study were chosen based on literature studies and direct relation with the parameter needed in the experiment. Ten anthropometric data were measured from each participant: stature, sitting height, hip height, knee height, shoulder to elbow length, sitting shoulder height, sitting waist height, hip breadth, elbow to grip length and shoulder breadth. These ten anthropometric data were chosen because they directly related to the driving posture. These seat parameters were used to investigate the correlation between the anthropometric data and comfortable driving postural angles.

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Driving postural angles were taken from three different cars with two different companies. The cars chosen are from compact and entry midsize segment cars. These cars represent the highest, average and the lowest ranks of cars used. The selected cars shared equal features on the drivers' seat such as manual adjustment of the seat track and the seat back, no armrest and standard fabric cover.

It is important to ensure the shared features so as to minimize the aesthetic effects on the participants' subjective responses (Kyung and Nussbaum, 2008).

3.2.4 Procedure

Prior to the data measurement process, the objectives and procedures of the study were explained in detail and participants were required to fill in their personal information in a form given to them. The measured anthropometrics dimensions were recorded in the same form. Before the postural angle measurement process was carried out, each participant anthropometric data was photographed and recorded. Participants are then required to sit on the driver's seat in their comfortable driving postures.

These seat adjustment parameters were taken after the seat had been adjusted by the participant according to their preference on driving comfort.

3.2.5 Statistical analysis: Data collection was made from Ujjain East to Ujjain West. The study was conducted on different age group from 20 to 65 years. The responses obtained through the data collection were tested to examine the validity and reliability of variable to obtain a statically proven identification of customer requirements. Data management and analysis was performed using SPSS tool. Statistical analysis involves a collection of methods used to evaluate large bulk of data and report the general trends obtained with highest scores. It is useful mainly while dealing with loud data. The various types of statistical analysis result include Candlesticks, point and figure charts, Pie-charts, bar figures and scatter plots. They are specifically created for users using large data inputs. The various statistical methods that are put into use to collate data inputs are:

1. Cross tabulation,
2. Frequencies,
3. Descriptives
4. Factor analysis,
5. cluster analysis (two-step, K-means, hierarchical) are used for prediction of identifying groups

IV. RESULTS AND DISCUSSIONS

The drivers consider the chair to be one of the most important factors for good comfort. Many drivers say that they get pain in the back and shoulders from their work. One driver says that it is better with the joystick steering when driving backwards so they don't have to do big movements with the wheel. The drivers say that the biggest work environment problems are:

- vibrations
- noise
- bad sight
- bad climate

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The anthropometric data and driver characteristics of the 77 participants were collected. Participants were 20-65 years of age (M = 57; F = 20), with differing levels of driving experience, ranging from (estimated) 1000 to 100,00 KM driven in Maruti and Hyundai. The age group between 20-30 year having valid percent 20.8 , 31-40 years is 36.4% and 40-50 years 27.3% while above 50 is 15.6%.

Table no. 1 Car Model * Gender Cross tabulation

		Gender		Total
		Female	Male	
Car Model	Alto 800	5	19	24
	Alto K10	4	8	12
	Hyundai Eon	5	3	8
	Hyundai i10	4	12	16
	Hyundai i20	1	4	5
	Maruti Celerio CNG Vxi	0	1	1
	Maruti suzuki desire	0	1	1
	Maruti Suzuki S-Cross	0	1	1
	Swift vdi	0	1	1
	Wagnor	1	7	8
Total		20	57	77

Table no. 2 Car Model * Age Cross tabulation

		Age				Total
		20-30	31-40	40-50	above 50	
Car Model	Alto 800	5	12	5	2	24
	Alto K10	2	5	4	1	12
	Hyundai Eon	3	2	1	2	8
	Hyundai i10	4	4	6	2	16
	Hyundai i20	0	1	2	2	5
	Maruti Celerio CNG Vxi	0	1	0	0	1
	Maruti suzuki desire	0	0	0	1	1
	Maruti Suzuki S-Cross	0	1	0	0	1
	Swift vdi	0	0	0	1	1
	Wagnor	2	2	3	1	8
Total		16	28	21	12	77

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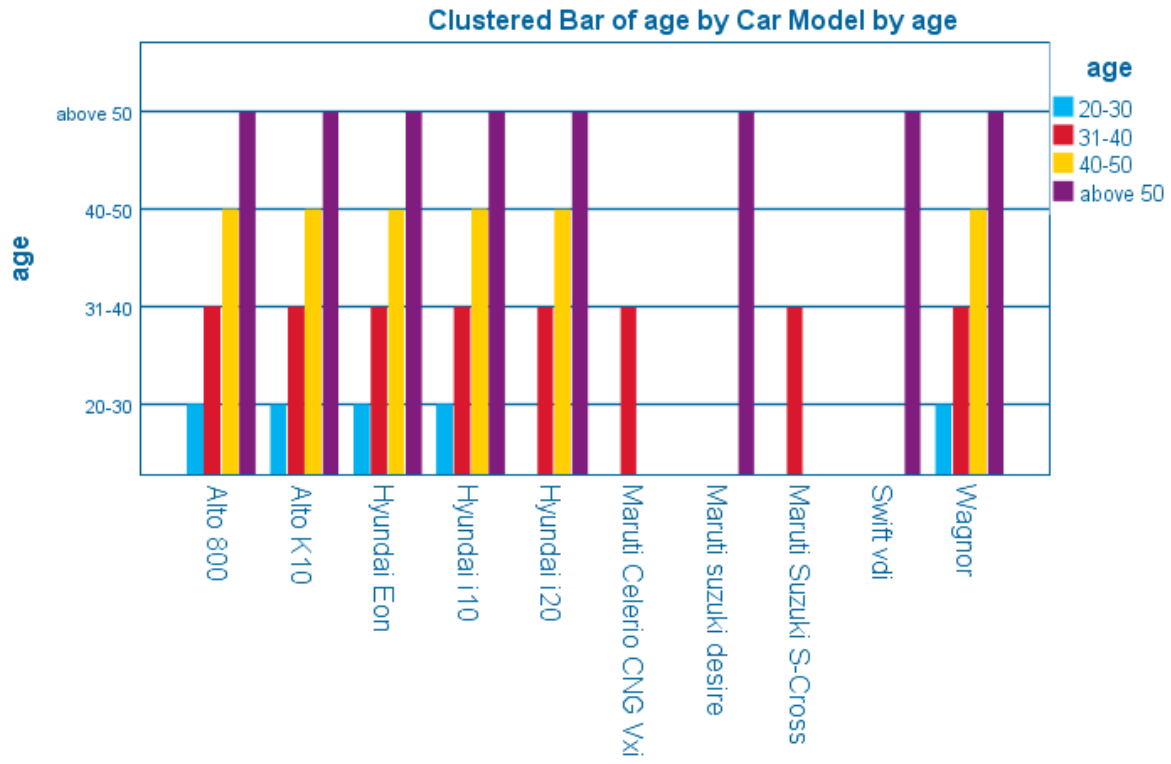

On average how many Km have you driven this vehicle in the last 12 months?

This question confirms that users driven throughout the year of and confirm the usage of vehicle. On the basis of received surveys, the user percentage is 53.2% in category of 5001-10000 km in a year. From the analysis, we found around 41 users out of 77 using their vehicle for short trip as the vehicle comfort is very low for long drive. The age group from 31-40 and 41-50 is 16 users in each.

Table no. 3 Age * Km Driven in Last 12 months

Age * On average how many Km have you driven this vehicle in the last 12 months Cross-tabulation						
		On average how many Km have you driven this vehicle in the last 12 months				Total
		1000-3000	3001-5000	5001-10000	Above 10000	
age	20-30	4	6	5	1	16
	31-40	3	3	16	6	28
	40-50	0	0	16	5	21
	above 50	4	0	4	4	12
Total		11	9	41	16	77

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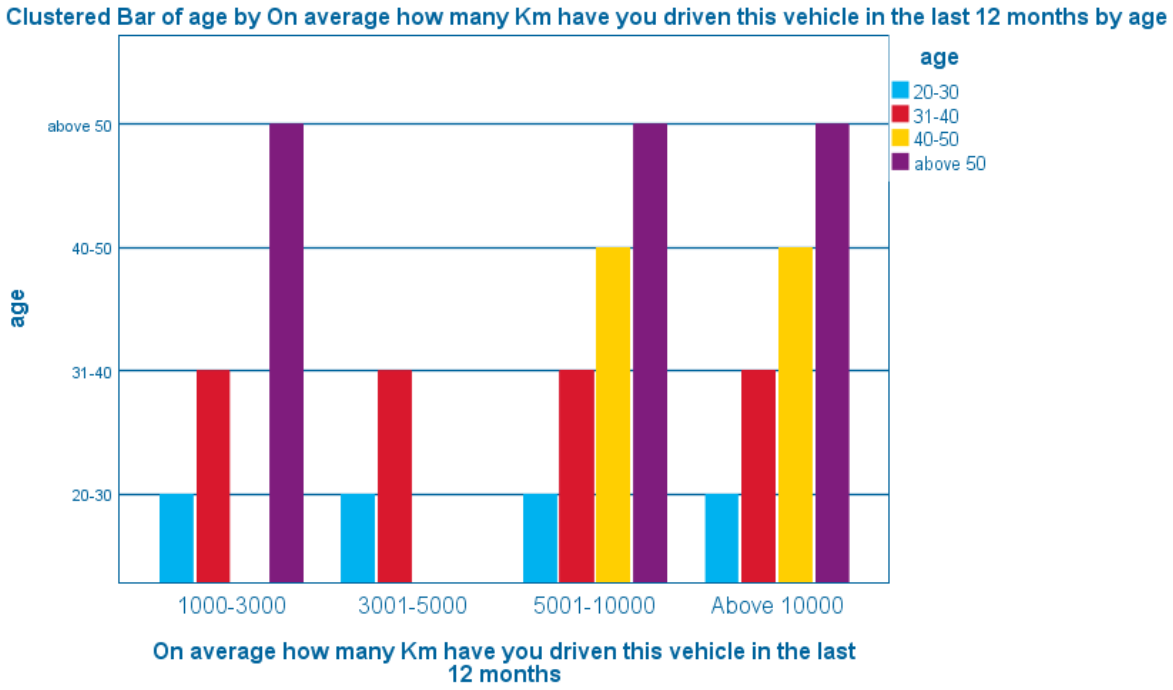

On average how many hours have you driven this vehicle in a typical week

From the survey data 77 respondents, we wanted to know how many hours have you driven this vehicle in a typical week.

Table no. 4 Age * On average how many hours have you driven this vehicle in a typical week Cross-tabulation

age * On average how many hours have you driven this vehicle in a typical week Cross-tabulation						
		On average how many hours have you driven this vehicle in a typical week				Total
		1 to 5	11 to 15	6 to 10	More than 16	
age	20-30	9	1	6	0	16
	31-40	2	3	21	2	28
	40-50	1	0	14	6	21
	above 50	6	4	1	1	12
Total		18	8	42	9	77

Have you at any time in the last 12 months had symptoms (such as ache, pain discomfort numbness or tingling) in:

A comfortable and safe driver's seat plays a very important role in car design and fabrication.

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77 data from participants were collected, from each participant: stature, sitting height, neck, knee height, shoulder to elbow length, sitting shoulder height, sitting waist height, hip breadth, and elbow to grip length and shoulder breadth. The muscular interaction with vehicle motions, sensed through the seat, is governed by anticipation of (experience) reaction and by a sense of balance. We found that seating comfort is very less in small segment car and 48.2% people experience pain in knees while they are going for long drive. These type of problems occurs generally the age group between 40-50.

Table no. 5 Have you at any time in the last 12 months had symptoms (such as ache, pain discomfort numbness or tingling) in cross- tabulation

Have you at any time in the last 12 months had symptoms (such as ache, pain discomfort numbness or tingling)					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Ankle or Feet	6	7.8	7.8	7.8
	Ankle or Feet, Shoulder or Elbow	7	9.1	9.1	16.9
	Knees	5	6.5	6.5	23.4
	Knees, Ankle or Feet	7	9.1	9.1	32.5
	Knees, Ankle or Feet, Shoulder or Elbow	2	2.6	2.6	35.1
	Knees, Shoulder or Elbow	7	9.1	9.1	44.2
	Neck	4	5.2	5.2	49.4
	Neck, Ankle or Feet	9	11.7	11.7	61.0
	Neck, Knees	12	15.6	15.6	76.6
	Neck, Knees, Ankle or Feet	4	5.2	5.2	81.8
	Neck, Knees, Ankle or Feet, Shoulder or Elbow	5	6.5	6.5	88.3
	Neck, Shoulder or Elbow	5	6.5	6.5	94.8
	Shoulder or Elbow	4	5.2	5.2	100.0
	Total	77	100.0	100.0	

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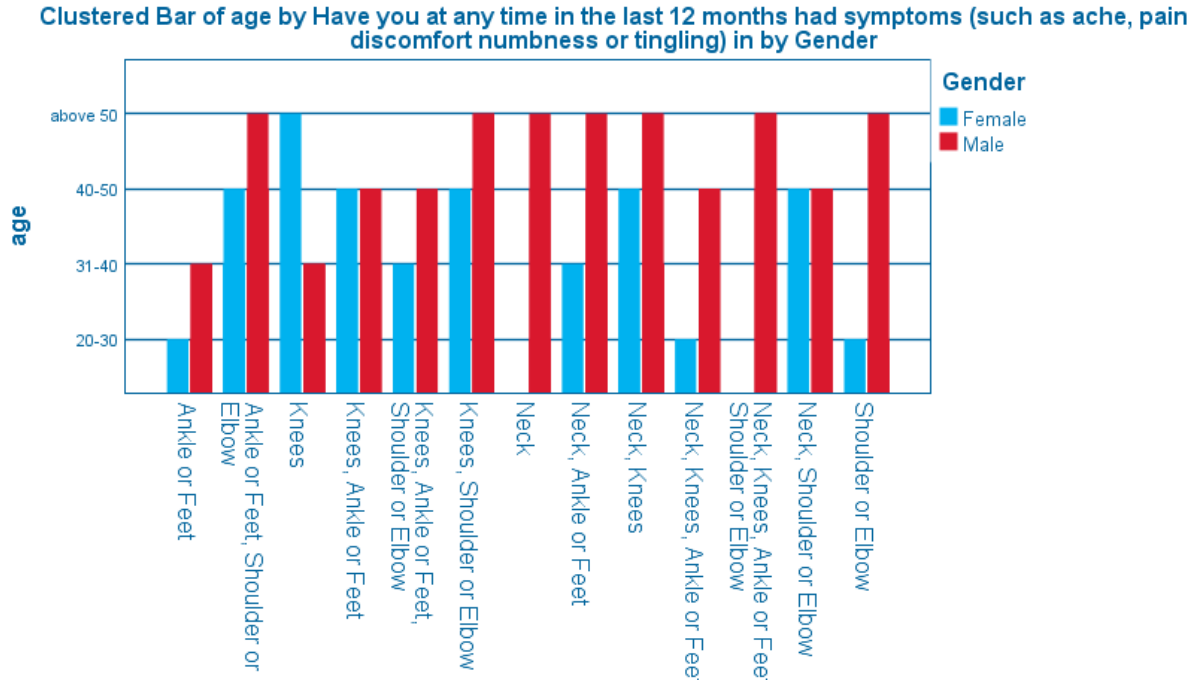

V. CONCLUSION

This study has explained the central importance of incorporating comfort in driver's car seat design. The results show that participants move significantly more in the static configuration and that they perceive more discomfort. The seat's comfort and support are evaluated significantly better in the dynamic configuration. Further research should investigate the effects in the context of driving on the road and an actual driving task. However, it can be concluded that the continuous movements of the seat have a beneficial effect on objective and subjective indicators of well-being. Result obtained and it confirms that 69% participants find the easy control over the vehicle .

Review of drivers

• 65% reported low-back pain
• 43% neck discomfort • 40% shoulder pain
• 1/3 of all drivers reported that they experienced moderate or severe low-back discomfort in a typical week
• Low-back related sickness absence is 6 times greater for those who drive >4 hours a day.

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