TO INVESTIGATE THE ASSOCIATION BETWEEN CURRENT CAR SEAT DESIGN WITH BODY POSTURE FOR REDUCING MUSCULOSKELETAL DISORDERS (MSD) THROUGH ERGONOMICS PRINCIPLES AMONG MALAYSIAN ELDERLY DRIVER

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ABSTRACT
The elderly community may continue to serve their serviced after pension. Therefore, elderly drivers need to take specific consideration during driving activities according to ability and capability to sustain their life and minimizing injury's and an accident. An ergonomics principles important to identify discomfort (mismatch) on seating posture based on National car seat design to sustain focus during driving according to Malaysian anthropometry measurement. This study also would determine association risk factors with current national car seat design and body posture at torso parts among elderly drivers within five's year before pension and after five retirements. A cross - sectional study implementing and purposive method sampling used base on inclusive criteria; age 55 - 60 years old and five years after retirement (65 years old), self-driving and driving a national car. The Modified Nordic questionnaire was used to determine the prevalence Musculoskeletal Disorders (MSD) injury history . Rapid Upper Limb Assessment (RULA) apply into this study to observed risk level the seating body posture. SPSS software used to analyse data and CATIA software apply into a study for simulation analysis on seating risk level body posture with design intervention base on anthropometry elderly drivers measurement. The final outcome from the study may reveal either existing car seat design manufactured based on Malaysian population specifically to elderly and also identify the low back pain injury and musculoskeletal disorders symptom faced by the elderly driver caused from the current car seat design. Advantages of this study could determine the best seating body posture according to anthropometry dimension and improving elderly drivers health, safety and comfort and reducing the accident rate. Also, increase the ergonomic production of National car manufactured in car seat design.

Key Words
Ergonomics, Elderly, body posture, car seat design , Musculoskeletal Disorders.

INTRODUCTION

The population older people rising rapidly than another age group as a one indicator for the developed country. Recently, Malaysia is now facing a challenge to the changing of the demographic profile of the population. Malaysia's population in the year 2000 approximately 23.3 million and this number will be continued grown year by year to achieve vision 2020. Expected the ageing community may continue to serve their services even though after pension, this influenced by their past environment. Besides that, elderly people need specific consideration to sustain their life according to ability and capability in the challenging world. However, the ageing issued should take place to discuss at the mainstream level specifically on transport manners. As we know, the motor industry largely ignored many of the issues to the elderly driver, with a lot of car designs, therefore, being unsuitable for drivers with age – related disabilities (Herriotts, 1997). According to Smith et al.

(1993), transportation is a key for an indicator of the quality of life and independence for elderly people and this has come to mean access to the private car. Hence, the characteristic of an elderly driver it so crucial to understanding, it may causes of the ageing process make elderly people more vulnerable to injury. Structure body elderly is too fragile compared to an adult, it takes less energy to produce tissue damage and disruption, and their skeletal structures are more easily damaged through bone loss. In short, there is a greater need improve the crash awareness of vehicles to provide better protection for elderly drivers and maintain their focus during driving. The accident rate could be decreased if emphasize an ergonomics principles in car seat design specifically into an elderly driver. Ergonomics is one of the significant factors to consider in designing a seat. Ergonomics is basically the applications of science in human life for comfort and safety. According to Kroemer et al. 2003, ergonomics is the application of scientific principles, methods, and data drawn from a variety of disciplines to the development of engineering systems in which people play a significant role. One of the most important contributions that ergonomics can provide to the automobile design process is information of the physical size of driver, and his/her preferred postures (Porter et al., 1998). A comfortable and safe driver's seat plays a very important role in car design and fabrication. As mentioned by Na et. al. (2005), drivers comfort was as important as the functional and aesthetic design of automobiles since users (elderly) were more and more concerned about safety and comfortable driving. Current bundling of the knowledge of comfort and discomfort has been limited while the need for this knowledge is crucial since people use products related to comfort every day (Vink et al., 2012). The application of ergonomics in ensuring comfortable and safe posture for elderly drivers to ensuring better lifestyle and insurance to them sustain focus on the road is the main focus of this study.

PROBLEM STATEMENT

Recently, vehicle designers predominantly focus their designs around young adult anthropometry, performance and exterior and interior design, which means that often the ergonomics specifications of vehicles do not necessary take account of needs of elderly people. A large of the literature revealed human body performance and physical has significant with age- related changes. An increasing age from the adult to the elderly stage will derive changes in physiological, sensory, perceptual, motor and cognitive abilities that may impact to elderly driver interact with vehicles and driving to sustain focus and comfort. According to Pruesser et al.(1998), ages – 65-69 years old driver were 2.26 times higher at risk of a fatal multi-vehicle crash compared to 40- 49 old drivers. To influence that factor to take parts become risk among elderly drivers is a human nature change – behaviour, physiology, attitude, character, emotion and focus significantly decrease with increasing ages. Furthermore, elderly drivers become more vulnerable to accident on the road during driving. Researchers found that, left turning driver judging the distance and speed of the road users is one of the factors frequent reported in Australia driver between an age of 74 and above (Larsen et al., 2002). 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. On the other hand, physical fatigue is mainly caused by driving posture (Hirao K. et al., 2006). That is why ergonomic approach had to be applied in ensuring comfortable driving posture. Fatigue is always associated with long duration of driving. Fatigue resulting from long-term driving can affect driver performance, which can be classified into physical and mental fatigue. On the other hand, physical fatigue is mainly caused by driving posture (Hirao et al. 2006). That is why the ergonomic method has to be applied in ensuring comfortable driving posture. Comfortable driving posture can also avoid the occurrence of any musculoskeletal problems and cognitive disorders. As shown by many past kinds of literature and studies, the importance of ensuring a comfortable and safe posture for car's drivers among elderly. An experiment conducted by Costanzo et al. (1999) found different levels of muscular fatigue between correct and incorrect postures. A field measuring device which was introduced by Hermanns et al. (2008) also shows that awkward postures and exposure to high vibration while in the driving position might result to high-risk condition for musculoskeletal

disorders. Car seat's design is an important to drivers feel comfort and safe especially elderly drivers on driving mode. The car manufacturer should incorporate body posture and anthropometry dimension according to the population in the design process for car seat. The sitting while driving needs to be differentiated from the comfort of sitting on a chair at various of an environment such as at home, in the office or at the workplace and factory or others industry. According to Andreono et al.(2002), driver's seat comfort in a car has distinctive comfort value compared to others types of seats. The comfort level could determine through body posture when she/he sit and drives. The drivers can show naturally discomfort if his body will feel pressured, burdened and emotion destruction. At the worst situation, elderly drivers will feel pain and injury at upper torso body part especially lower back body part. The elderly body muscle fragile and easy to obtain injury and take times to recover compared to youngest people.

The body dimensions elderly drivers need take part in setting up and build car seat design to ensure the elderly drivers sustain focus on the road and minimize MSD's factors. Anthropometric data which differ according to the population should take into account into seat design. Every region for a population on the anthropometry data is different from another and this can review in the slight difference in anthropometric data between the elderly driver or young drivers in the United Kingdom and Norway (Bolstad et al., 2001; Haslegrave, 1998). The different size of the population may influence by others factors; ethnicity, races, foods consumption and socio-demographic. The research was conducted by Baba Md Deros et al. (2015), Malaysian population have a smaller physical body size compared to American and European, thus, there is a wide significant difference with respect to their anthropometric data. Even though there had been many past researcher and experiments that had been conducted in driver's car posture (Falou et al. 2003, Hermanns et al. 2008, Hirao et al. 2006, Park et al. 2000, Andreoni et al. 2002, Na et al. 2005, Gyi & Porter 1999, Kyung & Nussbaum 2008, Reed & Manary 2000, Sun et al. 2006) but none was conducted specifically elderly drivers at Malaysian perspective. So, the aim of this study is to recommend comfortable design and safe driving postures preferred by Malaysian elderly car's drivers. In addition, it is interesting to investigate the relationship between the subjects anthropometric data with the comfortable postural angles measured.

AIMS OF THE STUDY

The aims of the study were to investigate either the current national car seat comply ergonomics principle into the design process with body posture (anthropometric dimensions) for reducing MSD's injury among elderly driver. The study also would determine others factor may influence to injury and accidents during elderly driving.

METHODOLOGY

This study uses the methodology of qualitative and quantitative. Quantitatively refers to data that are obtained using a set of questionnaires distributed to the participants to obtain the data the population. The types of questions used are more to structured questions and focused respondents on answering. These types of method are used to profile the populations at risk and study the method of adaptations and mitigation that is practiced before, during and after intervention.

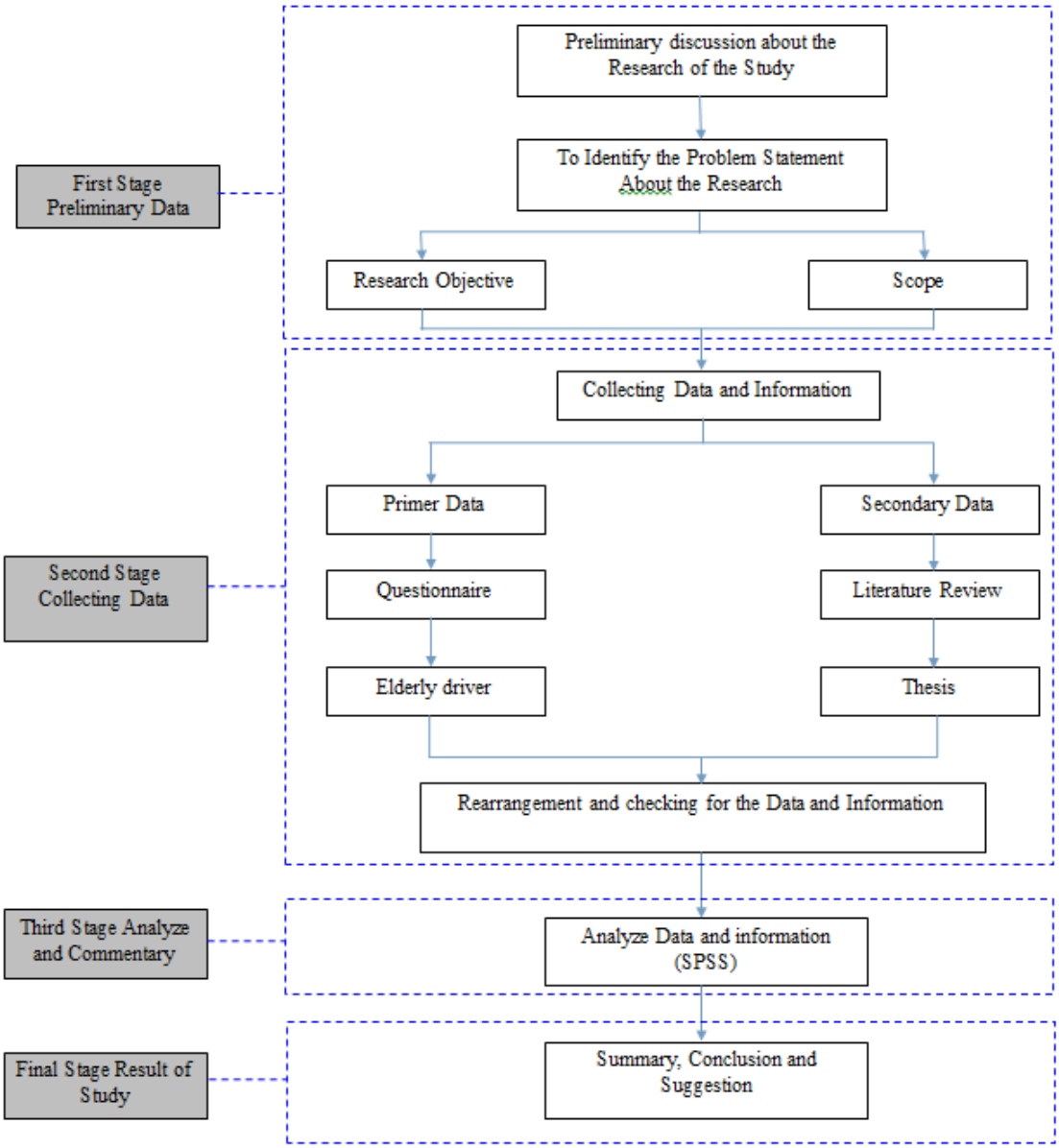

Figure 1: Methodology Flowchart

Basic design process

When designing a new product or new innovation, there is a need to implement ergonomics principles particularly using anthropometric data when designing product (car seat). The design produced may not function properly if it is not compliance with ergonomics principles (Haslegrave, 1986). Should ergonomics principles is not taken into consideration, this may affect the operational efficiency, unsafe for use and also increase the discomfort to the user (Gite & Singh, 1997).

Therefore, five compulsory consideration needed to be emphasized in developing ergonomics product for elderly seat driver including:

- Anthropometric measurements based on users.
- Risk factors may lead to the musculoskeletal symptom (MSS) such as awkward body posture during seating driving.
- The position of seating angle/arrangement
- Mismatch of size among elderly driver with a car seat.

- Aesthetics value in design.

Figure 2 shows the production process of a design:

- Step 1(research) - identify the objectives of the study and the problems faced by an elderly driver while driving.
- Step 2 (abstract ideas) - identify the concept designs to be produced.
- Step 3 (development of the preliminary design) – Freelance designers draw any concepts and idea generation without limiting the limitations of technology.
- Step 4 (detailed design) – Drawing sketches had been increased for the purpose of the idea can be refined and the application to be used can be identified.
- Step 5 (verification of the design) – Only one sketch selected based on the features and functions that have been set.
- Step 6 (model) - The mock-ups are produced using non-real (bread foam, cardboard, etc.). Size mock-up produced based on the actual size or half the size of the original designs based on the features that have been set.
- Step 7 (prototype) - Development of a full-scale prototype generated based on research information using real materials.
- Step 8 (improvements) - A series of prototypes produced for the purpose of improving the design to function better.
- Step 9 (test design) – Test of prototypes design was done on real research field. This test is important to prove the effectiveness of the design.

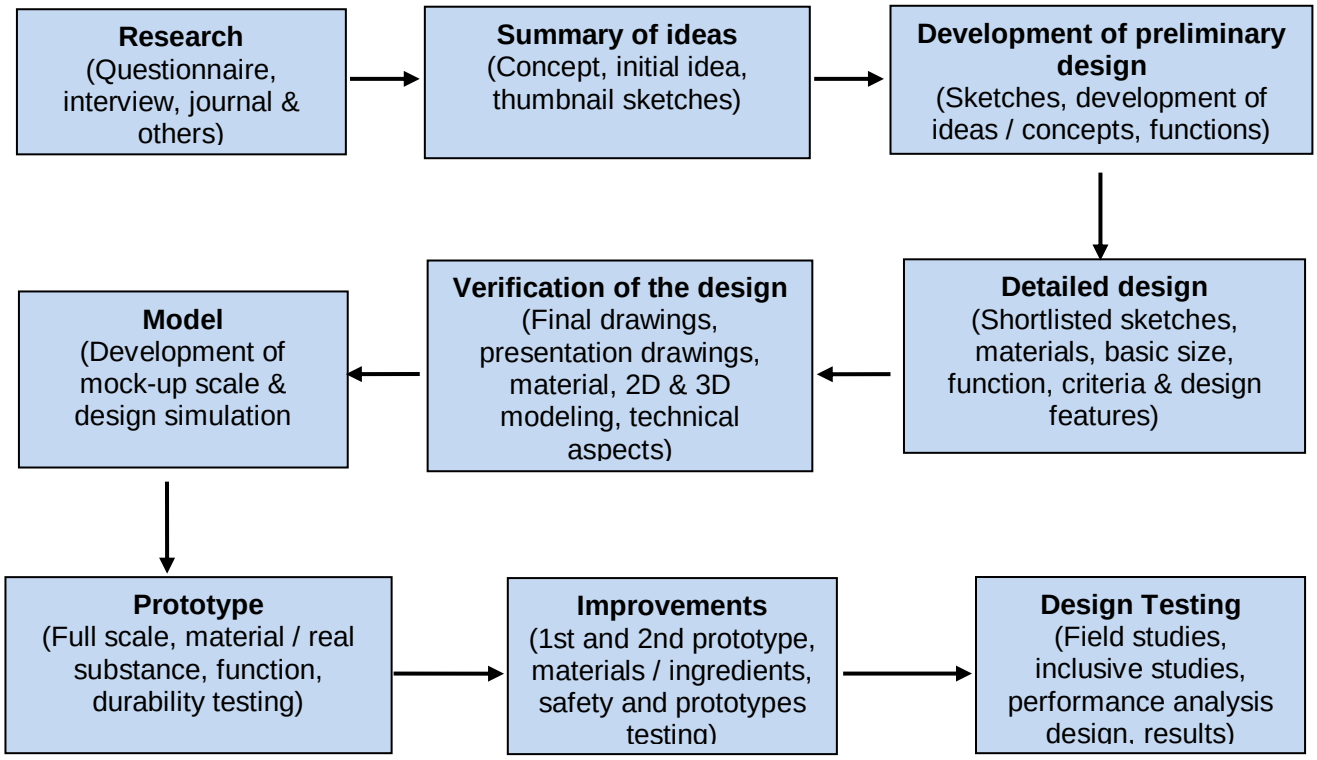

Figure 2: Design Process in developing car seat design for elderly driver.

- **Study background**

A cross - sectional study implementing and purposive sampling method applied to recruit respondents based on the selective criteria including age 55 - 60 years old and five years after retirement (65 years old), self-driving. And no handicap. Those driving except national car (Proton &

Produa) were excluded from the study. The purposive sampling method used in the study as the study area and the number of samples is determined based on the number of the elderly driver who work government sector which is the public university that has met the study criteria.

- **Questionnaire**

Interview method is implemented using questionnaires between elderly driver. Before the interview, consent letter presented and are required to be signed by the elderly driver. Interviews conducted after to avoid disrupting of their working time. Each interview done only takes about 20 minutes each. Prior to the questionnaire session, an elderly driver has brief in advance pertaining to the purpose of the study, the types of activities performed. All personal information associated with the elderly driver is confidential and will not be made public. There are seven sections of the questionnaire namely part A: background information on the respondents, part B: job information, part C: information / social lifestyle, part D: health study elderly driver based on the method of "Standardized Nordic Questionnaire" (Kuorinka et al., 1987) , and part E: information on car seat design. Part F is where anthropometric measurements and seat were written after anthropometric measurement and seat measurement was conduct.

Instruments

- **Video Recording**

Video recording method is used to record the position of the elderly body posture while seating in the car and driving. The recordings only run on an elderly driver that driving a national car for more than one month. The recording duration for each elderly while seating in the car after adjustment the seat before driving task to take about 10 minutes per video. The purpose of this recording is to analyze the elderly body posture while seating before and during driving in awkward condition through RULA analysis method.

- **BMI**

Calibrated weighing balance type "761 SECA weighing scales" was used. Weighing balance is placed on a flat surface until the needle scales show a reading of zero. Respondents asked to stand on scales with straight posture and both legs closed and the head facing frontward (Pheasant & Haslegrave, 2006). Measurements are taken and recorded as per showed in Figure 3.

Figure 3: Weight scale- "SECA 761

- **Design Simulation**

To run the simulation of new designs, software CATIA V5R16 version (Patent No. 5,615,321) is used. In this CATIA software, a manikin measurement is developed based on the anthropometric measurements size of the elderly driver. The anthropometric measurements of the manikin formed are based on the average size of elderly and population base on elderly anthropometric Asian population. Therefore, the comparison of the simulation analysis posture for ergonomic risk factors in the study using a new design done by RULA simulation methods in software CATIA.

- **Muscle test (Hand)**

Electromyography (EMG) wireless has been used to measured energy generated at selected muscle body parts for each elderly driver. Brand Trigno Personal Monitor (DELSYS) for EMG was selected. Each of driver required to attach the channel point as per - showed at Figure 4 at the selected upper torso muscle bodies parts has been identified. The estimated EMG data for each of harvesters during performs the task is 10 minutes per person. These EMG purposely use to compare the energy generated between conventional car seat design and new improvement car seat design.

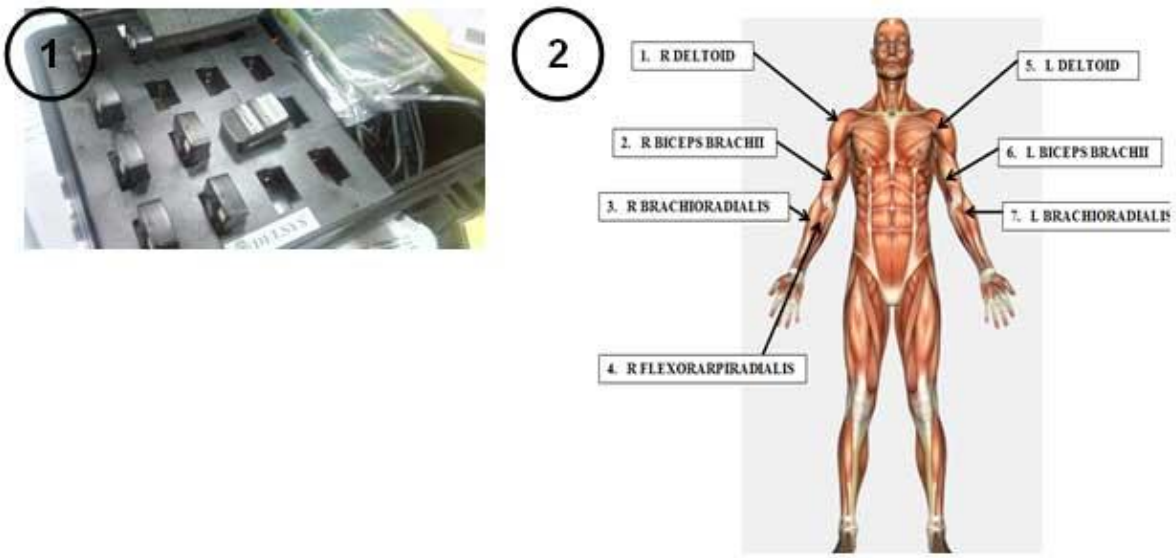

Figure 4: 1). Electromyography wireless,2) body parts which channel has been attached.

- **Rapid Upper Limb Assessment (RULA)**

The posture of each of driver performing their posture by a seat on the car after adjustment before and during driving was recorded using a video recorder. This process is intended to capture the posture of the elderly driver body posture on the seating degree and during performed the task (driving). Each video focuses on the most extreme position on posture elderly on the seating degree and character. Video footage was provided 10 minutes for each driver to perform their task. By using this method, the postural risk factors of the upper parts of the body can be identified. Rapid Upper Limb Assessment developed by McAtamney, L. & Corlett, E.N. (1993) was used to assess the posture adopted by the elderly driver. The method uses as shown in Figure 5. The classification of the posture analysis would indicate whether the work performs need changes for improvement or should be maintained.

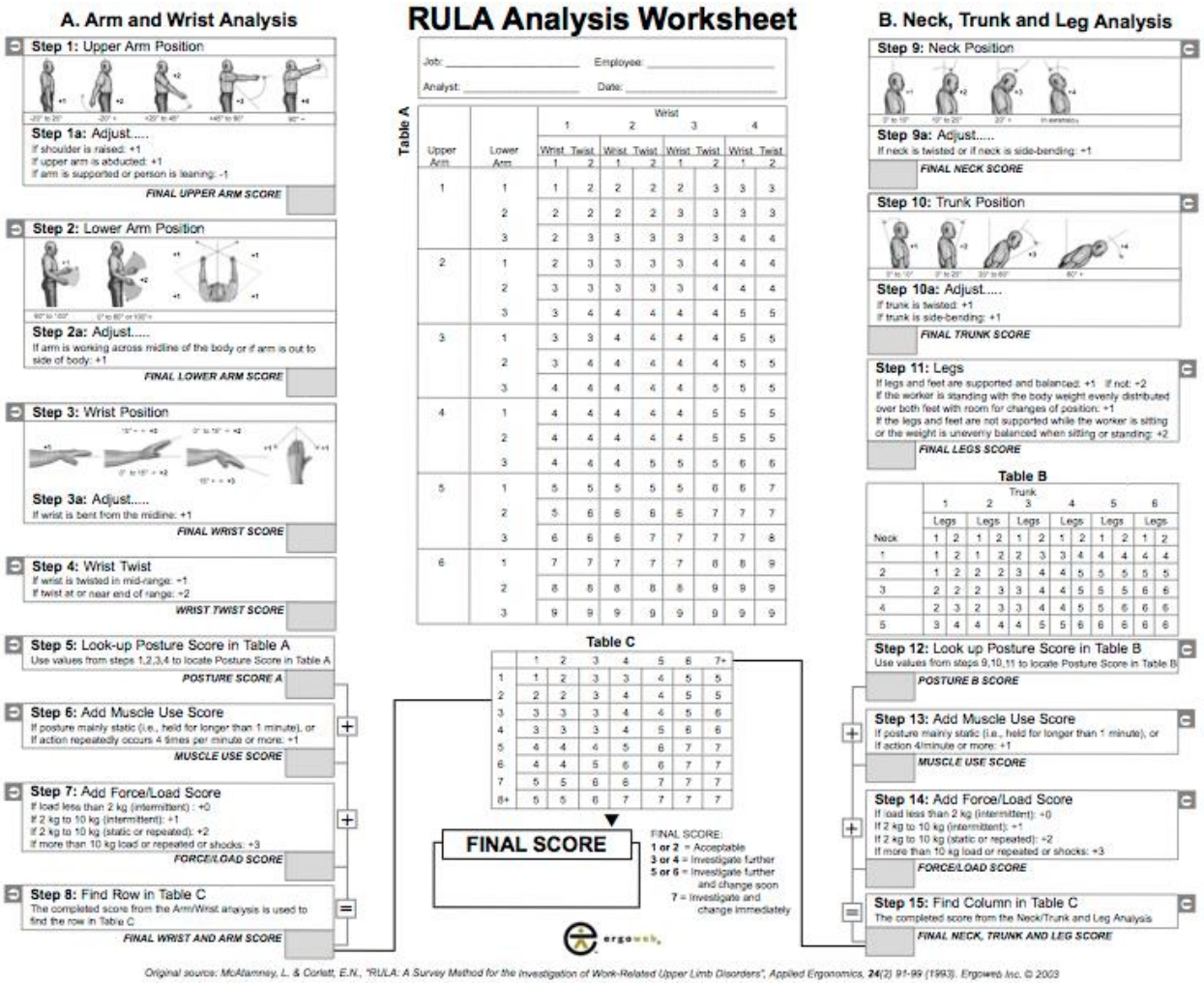

Figure 5: RULA Method in assessment of posture

By using RULA method as shown in Figure 5, real-time observation involves three main steps: 1) selection of postures 2) posture score by using score analysis 3) changing the score to the action level. The body is divided into Group A and Group B. Group A comprises the upper limbs, lower arm and wrist. While Group B, includes the neck, torso and legs.

Step 1, the evaluation begins with an observation on the number of rounds for the selection of work task postures. In general, the posture chosen selected based on the extreme working conditions and the frequency it happens. RULA form covers every part of the body involved.

Step 2, each of score from group A and B will be considered in which each score represents the inserted posture based on a combination of the parts of the body posture. Nevertheless, the load and the muscles used in the skeletal muscle is the cause of the excessive use of work, repetitive movements and excessive energy consumption needs or maintain additional load added to each group A and B. The total score of group A, muscle and energy will be included in the group C. Meanwhile, the total score of group B, muscle and energy recorded in group D.

The final Step 3, the total score is calculated by the score group C and D. The overall score from 1 to 7 based on the expected risk of injury caused by skeletal muscles involved. Postures of action and work on the overall scores 1 and 2 are considered acceptable. Overall score 3 and 4 means, further investigation and changes may be required. An overall score of 5 and 6 describe the investigation and

changes are required immediately. The overall score 7 indicates that investigation and changes are required immediately. Table 1 showed the grand RULA scores.

Table 1: Classification of RULA score

Score	Description
1-2	Indicates that the posture is acceptable if it is not maintained or repeated for long periods of time
3-4	Indicates that further investigation is needed and changes may be required
5-6	Indicates that investigation and changes are required soon
7	Indicates that investigation and changes are required immediately

- **Data Analysis**

All the data analyse using statistical software - SPSS (Statistical Package for Social Sciences) version 20.0. Table 2 showed four types of test analysis has been used 1) Descriptive test, 2) Chi square test, 3) Binary logistic regression, and T- test.

Table 2 Statistical test

Statistical test	Objective
Descriptive	Determine prevelans: • Soci - demographic • Workers information • Leisure activity • MSD • Design(seat) information
Chi Square.	Determine association to MSD risk factors.
Binary logistic regression	Determine correlation between MSD (upper torso parts and low back): • Soci – demographic • Workers information • Leisure activity • Design(seat) information • BMI
T- Test	To evaluate the effectiveness new improvement seat design with conventional seat (low back muscle usage).

- **Calculation of mismatch**

To determine the mismatch, the previous study that has been done by (Gite and Yadav, 1989) stated that a mismatch has defined any value that is greater than 95% or less than 80% of the reference subject. For example, a mismatch of the length of buttocks to popliteal to cushion length as any

length of cushion that is either more than 95% or less than 80% of the length of buttocks to popliteal. Then to establish the sensitivity of the result, the result was then changed in the definition of mismatch, to firm definition of mismatch: either more than 99% or less than 80% as proposed (Claudia et al., 1999) was employed in this study to determine mismatch. For mismatch length of buttocks to popliteal and length of cushion, it is defined as any length of cushion that is either > 99% or < 80% of the length of buttocks to popliteal. For value less than 80% was considered as a high mismatch, more than 99% consider as low mismatch and any value lies in the range 80% to 99% it was considered as matching. Summary of calculation of the mismatch is shown in Table 1.

Table 1: Summary of methods & valuation of mismatch study

Mismatch rating (Claudia P et al.,1999)			
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 & tools (Respondents reference)	95% total population of the respondents		
95%tile	Respondent's length of buttocks to popliteal	VS	the length of the Cushion
5%tile	width of buttocks	VS	The width of the cushion

EXPECTED FINDINGS

This study may found the current car seat design doesn't meet the anthropometric data for the elderly driver according to ergonomic principle. The impact of that case, various of negative view could contribute to an elderly driver such as lack of focus during driving, one of accident factors, emotional distraction, MSD's - low back pain. This study also will offer an overall picture of the crash situation leading o fatal injuries which are related to body posture dimension and car seat design among older drivers in Malaysia. The fact that, yet data available from literature discussed specifically elderly driver on discomfort (anthropometric data and current car seat design - national car) and also difficult to find the research focus on elderly body parameter in Malaysia population. The final outcome from the study may reveal either existing car seat design manufactured based on Malaysian population specifically to elderly and also an investigate the low back pain injury and musculoskeletal disorders symptom faced by the elderly driver caused from the current car seat design.

CONCLUSION

Malaysia has their own car manufacturing company thus, the improvement and innovation in increasing the production are highly needed. Most of the process involved in driving are highly exposed to fatigue and excessive force on the drivers which is one of the ergonomic risk factors for them. Safety and health of the drivers are important to avoid unfortunate accident and fatalities on the road. Thus, the advantages and importance of the study :

- Improve the car elderly drivers' health, safety and comfort.
- Increase the ergonomic production of car seat industries.
- Ensure the driving posture is ergonomically conducted.

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