ERGONOMIC ASSESSMENT OF DRIVER’S SEAT OF TAXICABS USED IN NIGERIA

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ABSTRACT

Workspace and Driver’s seat design in particular play significant role in the comfort, performance and safety of driving task. Reduction in associated safety and health risk of work related problems can be readily enhanced through the use of a well designed participatory ergonomic intervention program. This study assesses ergonomic characteristics of occupational driver’s seat found in Taxicabs used for public transport in Nigeria. Five commonly used taxicab models were selected for the investigation. A total of 1409 taxicab drivers were considered. A three dimensional macro-ergonomics evaluation Technique (3D-MET) was used to analyze the interrelationship between the subjects (driver), the object (vehicle) and object conditions (in-vehicle elements). Six ergonomic criteria were assessed while nineteen seat variables were analyzed. Significant cases of potential misfits were observed on some cab’s workplace features. Mazda’s seat design had better acceptability while ease of use was rated well for all the vehicles except Nissan. The identified constrained posture was observed
to have resulted in increased discomfort and health risks. Application of Ergonomics to the design of technological system element then become a necessary step to the development of user-friendly, comfortable and save work system. The 3D – MET revealed that Mazda had the best ergonomic assessment.

**KEYWORDS:** Seat, Comfort, Musculoskeletal disorder, PEI. 3D-MET

1.1 INTRODUCTION

The development of comfortable seat is an important goal in automobile industry. Investigations have identified and proved seat design as a major risk factor influencing back pain in drivers despite vivid efforts in vehicle seat design and back care advise for use of a lumber support to maintain good posture (Handley and Haslegrave, 2002; Adams and Hutton, 1983; Duncan and Ferguson, 1974; Hunting, *et al.*, 1980 and 1981; Graf *et al.*, 1995; NIOSH, 1997). Low-back pain was reported as a prevalent musculoskeletal disorder (MSD) common among tractor drivers especially when exposed to whole body vibration and posture stress (Bovenzi and Betta, 1994). Research has also revealed that among a sample of occupational drivers 65% reported low back trouble, suggesting the need to develop an intervention to reduce MSDs among occupational drivers (Kroemer, *et al*., 2000; Funakoshi, *et al*., 2003; Hsiao, *et al*., 2005; Durkin, 2006; Okuribido, 2007). Epidemiological studies have shown that vehicle drivers have a high prevalence low back pain which results from poor sitting posture held for long durations (Hannerz and Tuchsen 2001; Handley and Hasleggrave, 2002; Porter and Gyi, 2002;and Koda, *et al*., 2000). Similar survey also indicated that drivers of automobiles were more frequent in low back pain (LBP) patients, with high cumulative trauma disorder (CTD) as annual mileage increases (Frymoye *et al* 1983, Porter and Gyi 2002). Other studies conducted by Gruber and Ziperman, (1974), Backman (1983) and Magnusson *et al*.(1996) related increase in low back pain (LBP) among experienced driver with age. Investigation into individual differences in working
techniques by Kilbom and Persson (1987) discovered that worker who worked in forward flexion of the neck and raised arm in a prolonged static posture ran a high risk of cervicobrachial disorders. Grandjean (1988) estimated that 50 percent of adults suffer back aches during at least one period of life and stated that the main reason for frequent backaches is a pathological degeneration of the discs which are between the bony vertebrae and act as an elastic cushion between vertebrae thus giving the spinal column its flexibility. Also Videman et al., (1990) found that both sedentary work and heavy physical work were associated with abnormalities of the spine and that static seating posture causes discomfort. Graf et al., (1993, 1995) reported more discomfort and chronic disorder among workers who sit in fixed postures.

Like some other work activities, driving of vehicle is usually carried out while seated in a fixed location within the driver’s workspace envelope. Importantly the design of the envelope is based specifically on the activities to be performed and the type of people who are to use the space. The data to be used in designing this workspace envelope was obtained through anthropometric studies of the operator (driver). Differences in human anthropometric parameters with ethnics, age, sex, and other demographic diversity suggest possible variations in their assessment of any technological facilities (Jeferrey, and Uppugonduri, 1992, Muzammil, et al., 2007).

This paper use PEI approach in which driver’s opinion is considered This approach allows the driver (a major component of the man-machine system) to make usefully contributions to the development of quantitative performance model for driver seat as well as in the design/redesign of an important in-vehicle component. It is expected that the involvement of driver in this evaluation study of vehicle seat will build trust, commitment, and good will which leads to increased job satisfaction and significant improvement in performance.
2.1 METHODS

Five Urban centres in Nigeria were selected and the opinion of 1409 taxicab drivers was considered on a sample of five prominent models of existing driver’s functional taxicab seats. The participatory ergonomic approach used involved the following steps

2.1.2 Training of Enumerators

Eight undergraduates students who have in the department of engineering who have taking three credit unit course in Introduction to Industrial Engineering were trained as enumerators. There were trained on some principles of ergonomics in relation to the use of the survey tools like 1) discomfort chart, 2) structured questionnaire, 3) data collection form, 4) method of interview and 5) seat features to be measured and assessed,

2.1.3 Preliminary Interaction

The trade union leaders in charge of the activities of the cabs’ operators registered with the name “National Union of Road Transport Workers (NURTW) were pre-informed and necessary authorization that ensure maximum cooperation from the drivers was obtained. The survey program was informally discussed and agreed upon.

2.1.4 Survey Workshop

A workshop designed to intimate member of the union who predominantly operators the taxicab with the objectives of the survey was conducted at the trade union house in each of the urban centres covered. Questions were asked and answered. Also remarks were passed on the relevance of the survey be the participants.
2.1.5 Interview

Fifty randomly selected participants were interviewed on their experience on the job and general assessment of different brands of cab seats and other in-vehicle elements. This interaction was addressed in line with the objectives of this study and to prepare potential respondents for the next stage of the investigation. Limitation as a result of lack of basic/formal education was mitigated through the personal discussions on the subject matter.

2.1.6 Administration of Questionnaire and Discomfort Chart

After the interview enumerators commenced the administration of the structured questionnaire which is targeted at exploring driver’s personal characteristics and opinion on the musculoskeletal problems they experienced on the job using the seat of available taxicab types. Discomfort chart was used. Six important ergonomic criteria which were assessed at this stage include 1) Chair adjustability, 2) Seat comfort, 3) Ease of use, 4) Body support, 5) Leg and thigh support and 6) Overall chair experience. Scoring model was employed to assess the level of performance using a range of 0 – 10 marks which were assigned to score seat performance based on three grades: unacceptable (0 – 4), average (5) and excellent (6 – 10). Also three questions of equal weight were drawn for each criterion while vehicle seat is assessed as percentage of total score (180).

2.1.7 Measurement of Seat Variables

Observational studies together with linear and angular measurement were also carried out on the sampled driver’s seats. The physical measurement of nineteen seat variables that was carried out on the sampled taxicabs include: Seat height, Seat depth, Backrest seat plane height, Backrest height, Distance from edge of seat to application of force point, Lumber support height, Lumber support depth Lumber support extension, Rounded front edge seat width, Armrest clearance, Backrest width (Lumber level), Backrest width (Thoracic level), Horizontal lumber concavity (Radius), Horizontal Thoracic concavity
(Radius), Headrest length, Headrest width, Armrest surface length, Armrest surface breadth, Backrest angle and Seat plane angle.

A three dimensional macro-ergonomics evaluation technique (3D-MET) was used to analyze the interrelationship between the subjects (automobile driver), the object (vehicle type) and the object conditions (in-vehicle element).

3.1 RESULTS AND DISCUSSION

Typical side view of driver’s workspace and its elements are presented in Figure 1. The seat has some adjustable features which allow users to set the seat for purpose of comfort, adequate supports and fitness of certain body segments. Figure 2 show the three dimensional macro-ergonomics evaluation technique (3D-MET) of the interrelationship between automobile driver opinion, vehicle type and the six considered seat conditions. From this result Mazda proved to have the highest average rating and acceptance of the user

3.1.2 Operator’s Assessment of Driver’s Seat in Nissan Taxicab

Assessors of driver’s seat design are strictly the sampled respondents of this survey. The assessment of Nissan vehicle used as Taxicab by the operators of the system based on the six criteria were generally rated average (rating = 5, 0.23<p<0.3) except “ease of use” which was rated unacceptable (rating = 4, p=0.27). This result suggests that there is significant opportunity for design improvement on ease of use of the seat as well as on other characteristics in other to accommodate operator’s anthropometric characteristics (Figure 3). Drivers must be able to adjust the height, the arm rest and as well as be able to recline the seat with little of no stress.

3.1.3 Operator’s Assessment of Driver’s Seat in Toyota Taxicab

Respondents assessment of driver’s seat in Toyota vehicle used as Taxicab show all the characteristics considered are rated as average (rating = 5, 0.23<p<0.29) except for “leg and thigh support” which was rated unacceptable
Ergonomic Assessment of Driver’s Seat of Taxicabs used in Nigeria

3.1.4 Operator’s Assessment of Driver’s Seat in Mitsubishi Taxicab

Figure 5 shows chair adjustment and ease of use in Mitsubishi are rated acceptable (rating =5, \( p=0.22 \) and \( p=0.198 \)) while all other characteristics are rated average (rating = 5, \( 19.5<p<25 \)). Overall chair support has rating that is much closer to that of ease of use for rating as unacceptable (rating = 4, \( p=0.195 \)). This evaluation suggests more effort on ergonomic suitability of Toyota seat to enhance safety, comfort and performance of the taxicab operators.

3.1.5 Operator’s Assessment of Driver’s Seat in Peugeot Taxicab

The evaluation of overall chair support as well as leg and thigh support of driver’s seat in Peugeot used as taxicab as shown in figure 6 is rated as unacceptable (rating = 4, \( p=0.36 \) and \( p=0.27 \)). Chair adjustment rating and body support are rated average (rating=5, \( p=0.22 \) and \( p=0.27 \)). Ease of use and seat comfort are however rated acceptable (rating = 6, \( p=0.26 \) and \( p=23 \)). The inadequacy of the seat system in Peugeot could be traced to lack of inclusion of the anthropometric characteristic of the respondent under study. Also observed is the age of the vehicle which rendered it obsolete in term of improvement which may have taken place on the ergonomic of the vehicle seat system.

3.1.6 Operator’s Assessment of Driver’s Seat in Mazda Taxicab

Respondents assessment of driver’s seat in Mazda taxicab shows that Chair adjustment, seat comfort and ease of use shows in figure 7 are rated as
acceptable (rating = 8, 6 and 6; p = 0.21, 0.21, and 0.23 respectively) while body
support, leg and thigh support and overall chair support are rated average
(rating = 5; 0.24<p<0.25).

3.1.7 Operator’s Seat Dimensions

Nineteen driver’s seat variables for Nissan, Toyota, Mitsubishi Peugeot, and
Opel were measured and presented in the Table 1. The mean (X̄) and standard
deviation (SD) of each variables taken for sample of five (n=5) of each of the
cabs. The standard deviations of the measurements ranged between 0 and 0.86,
for linear measurement and 1.14⁰ and 2.88⁰ for angular measurement. Variability
of the seat dimensions were significant (p=0.05) at some points especially the
lumber support of the cabs. This is the for the rounded front edge seat width.
Few of the measurements were very close in value these included armrest
clearance, armrest surface length and armrest surface breadth.
Figure 3: Ergonomic Assessment of Driver Seat in Taxicab (Nissan)

Figure 4: Ergonomic Assessment of Driver Seat in Taxicab (Toyota)
<table>
<thead>
<tr>
<th>Rating</th>
<th>Hair Adjustment</th>
<th>Seat Comfort</th>
<th>Ease of Use</th>
<th>Body Support</th>
<th>Leg and Thigh Support</th>
<th>Overall Chair Support</th>
<th>Rating of Evaluation Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>5.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Figure 5: Ergonomic Assessment of Driver Seat in Taxi cab (Mitsubishi)

Figure 6: Ergonomic Assessment of Driver Seat in Taxi cab (Peugeot)
Ergonomic Assessment of Driver’s Seat of Taxicabs used in Nigeria

Figure 7: Ergonomic Assessment of Driver Seat in Taxicab (Mazda)

Table 1: Seat Characteristics (cm) of Studied Taxi Cabs

<table>
<thead>
<tr>
<th>Seat Characteristics (cm)</th>
<th>Nissan</th>
<th>Toyota</th>
<th>Mitsubishi</th>
<th>Peugeot</th>
<th>Mazda</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>𝜇</td>
<td>SD</td>
<td>𝜇</td>
<td>SD</td>
<td>𝜇</td>
</tr>
<tr>
<td>Seat height</td>
<td>0.35</td>
<td>0.35</td>
<td>0.35</td>
<td>0.35</td>
<td>0.35</td>
</tr>
<tr>
<td>Seat depth</td>
<td>43.4</td>
<td>0.45</td>
<td>44.2</td>
<td>0.45</td>
<td>43.2</td>
</tr>
<tr>
<td>Backrest seat plane height</td>
<td>56.5</td>
<td>0.50</td>
<td>56.6</td>
<td>0.50</td>
<td>57.6</td>
</tr>
<tr>
<td>Backrest height</td>
<td>51.8</td>
<td>0.57</td>
<td>55.5</td>
<td>0.57</td>
<td>51.8</td>
</tr>
<tr>
<td>Distance from edge of seat to applied force point</td>
<td>8.9</td>
<td>0.22</td>
<td>7.8</td>
<td>0.22</td>
<td>8.5</td>
</tr>
<tr>
<td>Lumber Support height</td>
<td>20.6</td>
<td>0.55</td>
<td>14.4</td>
<td>0.55</td>
<td>21.2</td>
</tr>
<tr>
<td>Lumber Support depth</td>
<td>8.4</td>
<td>0.55</td>
<td>5.3</td>
<td>0.45</td>
<td>8.8</td>
</tr>
<tr>
<td>Rounding front edge seat width</td>
<td>16.1</td>
<td>0.22</td>
<td>23.3</td>
<td>0.45</td>
<td>16</td>
</tr>
<tr>
<td>Armrest clearance</td>
<td>58</td>
<td>0.00</td>
<td>58.2</td>
<td>0.45</td>
<td>58.9</td>
</tr>
<tr>
<td>Backrest width (lumber level)</td>
<td>31</td>
<td>0.35</td>
<td>30.7</td>
<td>0.84</td>
<td>31.3</td>
</tr>
<tr>
<td>Backrest width (Thoracic level)</td>
<td>53.2</td>
<td>0.45</td>
<td>53.1</td>
<td>0.74</td>
<td>53.4</td>
</tr>
<tr>
<td>Horizontal lumber concavity (Radius)</td>
<td>44.7</td>
<td>0.45</td>
<td>56.3</td>
<td>0.45</td>
<td>45.1</td>
</tr>
<tr>
<td>Horizontal Thoracic concavity (Radius)</td>
<td>39.3</td>
<td>0.45</td>
<td>48.6</td>
<td>0.55</td>
<td>39.5</td>
</tr>
<tr>
<td>Headrest length</td>
<td>20</td>
<td>0.00</td>
<td>17</td>
<td>0.00</td>
<td>17.1</td>
</tr>
<tr>
<td>Headrest width</td>
<td>27</td>
<td>0.00</td>
<td>24.1</td>
<td>0.00</td>
<td>26.1</td>
</tr>
<tr>
<td>Armrest surface length</td>
<td>6</td>
<td>0.00</td>
<td>5</td>
<td>0.00</td>
<td>5</td>
</tr>
<tr>
<td>Armrest surface breadth</td>
<td>31.1</td>
<td>0.22</td>
<td>29</td>
<td>0.00</td>
<td>32.9</td>
</tr>
<tr>
<td>Backrest angle</td>
<td>112.2</td>
<td>1.79</td>
<td>108.2</td>
<td>2.77</td>
<td>109.6</td>
</tr>
<tr>
<td>Seat plane angle</td>
<td>109.4</td>
<td>1.95</td>
<td>108</td>
<td>1.95</td>
<td>104.4</td>
</tr>
</tbody>
</table>
4.1 CONCLUSIONS

The ergonomic evaluation of driver’s seat of five commonly used Taxicabs models in the study area based on criteria such as chair adjustability, seat comfort, ease of use, body support, leg and thigh support and overall chair experience using the participatory ergonomic intervention (PEI) approach suggests possible improvement on some features of driver’s seat and/or his workspace. Some other elements of the in-vehicle which were also evaluated show the need for vivid effort on the improvement of their design so as to fit and make driving task more comfortable and safe for the drivers. As a result of the non-uniformity of the seat in the make of Taxicabs, operators of should necessarily be able to adjust the seat to as to establish a safe, comfortable and effective relationship with the seat, steering column and wheel, control buttons and pedals. Proper interaction with these in-vehicle components may influence improved operator’s posture.

Likewise driver’s seats and other relevant workspace features of the selected Taxicabs were characterized considering nineteen different variables. The design parameters of the operators’ workplace and its constituents considered by automobile manufacturers have proved to work against the expectations of drivers in the considered centre. Prominent among the considered features of driver’s workplace are leg room, roof height and seat belt design which are designed for 5th and 95th percentile of adults population under consideration do not readily fit the studied Taxicab operators. This survey has identified poor seat design, state of disuse of vehicle seats, and poor adjustable range and control as responsible for continue damage on sitting posture of drivers. Amongst the potential risk factors within a taxicab is seat design which is significantly responsible for lower back pain in drivers. The identified constrained posture was observed to have resulted in increased discomfort and health risks. Application of Ergonomics to the design of a technological system then a necessary step to the development of user-friendly, comfortable and save work
system. User of such system also have key role to play in the successful implementation of ergonomic changes as operators of a facility do have unique knowledge about the system they operate and in many instances they know valid solutions to ergonomic problems.

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