Ergonomic Risk Assessment and Postural Analysis of Indian Auto-Rickshaw Drivers using RULA and REBA

Agarwal P.K., Paul D., Kumar V. and Banerjee D.
Production Engineering Department Jadavpur University, Kolkata, West Bengal, India
Email id: punitagg@gmail.com, debapriyopaul@ymail.com

Abstract: The objective of this research is to assess the ergonomic risks associated with Indian auto-rickshaw drivers and suggest necessary modifications and improvements for the development of a new hybrid auto-rickshaw that is better suited ergonomically for its drivers. The ergonomic risk is measured by analyzing the different postures attained by drivers. The main tools that we have used for this purpose are RULA (Rapid Upper Limb Assessment) and REBA (Rapid Entire Body Assessment). A total of 25 drivers were interviewed for this purpose, all of them plying the Jadavpur 8B-Tollygunge Metro route. A REBA score of 7-8 (considering different postures) signifies that there is a very high risk of developing a musculoskeletal disorder. Assessment of ergonomic risks using RULA gave a score of 5-6 (considering different postures) which suggests that necessary changes must be implemented immediately. So as to minimize the associated ergonomic risks, a host of modifications were suggested in the design of auto-rickshaws. The scores of RULA and REBA, computed after implementing the said modifications in the simulated model generated using JACK- 8.0.1 showed that the ergonomic risks had been reduced considerably.

1 Introduction

In a country with a population of over 1.2 billion people, it is evident that transport represents a critical portion of the Indian economy. Most the population being comprised of the poor and middle-class implies that public transportation is the primary means of travel, and it is a well-known fact that India's public transport systems are among the most heavily used in the world. The auto-rickshaw, one of the vehicle types falling under this category, is one of the most popular modes of transportation in India. An auto rickshaw is a three-wheeler vehicle for hire that does not have doors and is generally characterized by a small cabin for the driver in the front and a seat for passengers in the rear. Generally it is painted in yellow, green or black color and has a black, yellow or green canopy on the top, but designs vary considerably from place to place. Auto rickshaws are used in cities and towns for short distances; they are less suited to long distances because they are slow and the carriages are open to air pollution. Auto rickshaws (often called "autos") provide cheap and efficient transportation. However, the fact remains that although the auto-rickshaw has undergone many changes so that it does not harm the environment, the deleterious effects that they have on the drivers have never been thoroughly explored from an ergonomic point-of-view and the ergonomics of the driver was never given much consideration from the time the vehicle was first conceived by Bajaj in 1959, inspired from the design of the Vespa two wheeler. The design of the handle-bar is such that it is bound to provide some discomfort to the drivers, especially while operating the vehicle at higher gears. Thus, the objective of the paper is to investigate the ergonomic risk that the auto-drivers are subjected to

whilst driving and for evaluation, we have chosen two well-known ergonomic analysis tools namely REBA [5] and RULA [8]. Both of these methods have been utilized extensively in the field of ergonomics for determining whether a particular posture or process or design is disadvantageous ergonomically [1], [2], [3]. The important researches where RULA and REBA have been utilized include those by Harmanns [4] and Jagannath [6]. Other important works related to ergonomic evaluation considering different driving scenarios like buses and trucks include those by [7], [9] and [10].

2 Materials and Methods

The data used in the current research were collected by actual observation and questionnaire. A total of 25 drivers were interviewed for this purpose, all of them plying the Jadavpur 8B-Tollygunge Metro route in Kolkata, India. The data was recorded by a single person so as to avoid discrepancies in the result. The photographs of auto-rickshaw drivers (shown in figure 1) were taken by considering different working postures in order to analyze the deviations in the postures from their respective normal conditions. Further, the associated ergonomic risks were assessed using RULA (Rapid Upper Limb Assessment) and REBA (Rapid Entire Body Assessment). The above mentioned evaluation techniques follow a simple approach wherein tables are filled based on the survey carried out by the researcher. In the present scenario, auto-rickshaw drivers remain seated in their seats for long hours and perform tasks that are dynamic in nature. Therefore, RULA was chosen since it is best suited for evaluating seated tasks, whereas REBA, on the other hand, can efficiently evaluate tasks that involve rapidly changing postures.

3 Results and Discussions

RULA and REBA scores were computed by analyzing postures of auto-rickshaw drivers while applying different gears (i.e. 1st, 2nd, 3rd and 4th gear) and also while taking a turn (as shown in Fig.1) .These scores have been shown in Tables 1 and 2. RULA score comes out to be 6 for each of the evaluated positions which suggests that the ergonomic condition of the job is very poor and should be changed immediately. Further, a score of 7-8 is achieved in case of REBA while evaluating different postures thereby signifying that the drivers have a very high risk of developing a musculoskeletal disorder and therefore necessary modifications should be implemented within a short span of time.

The scope for improvement in the present state can be approached from the following two directions:

i. Improvements in the design of driver's seat

ii. Improvements in the design of handle bar by suggesting an alternative solution

3.1 Design of seats: The seats of auto-rickshaws are pretty much straight, padded benches with straight, padded backrests. The auto-rickshaw's driver's seat is a work place occupied by the driver for many hours each day. Figure 2 shows a human model, representing the 50th percentile of the Indian male population. To the left the figure is sitting with its back against the backrest, its hands on the handlebars, its left foot resting on the floor and the right foot on the brake pedal. The right hand figure is seated according to observations made of auto-rickshaw drivers. When placing the figure on the right it became clear that the backrest could

not be utilized from this position. Hence there is room for improvement, especially in the coordination between seats, back rests, pedals and controls.
The adjustments that were considered while suggesting modifications in the design of seats were seat height, seat tilt, backrest tilt, seat movement backwards/forwards, steering wheel height and backrest height. Fig. 3 shows a new driver's seat that is designed with a separate backrest for providing lumbar support, as well as some higher support, and is situated about 15 centimeters above the seat. To enable the driver to change his posture by small amount, the backrest was flattened slightly. The angle between the seat and the backrest was decreased slightly to reflect the evaluated posture. The angle of the seat was increased in order to better follow the back of the thighs.
3.2 Design of Steering Wheel: The reason many auto-rickshaws use handle bars instead of steering wheels is that the auto-rickshaw originally is a modified motorcycle and therefore the handle bar has kept its place, but when designing from scratch, a steering wheel allows a more ergonomic posture. To place the controls used while driving on/around the steering wheel, a space efficient layout had to be chosen. Buttons were the most space efficient controls when comparing different ways of putting the controls on the steering wheel. Hence the steering wheel concept seen in Fig. 4was developed. The outer shape with a flattened bottom curve allows more leg room for the driver. The shape of the center part of the steering wheel has room for buttons and doesn't block dashboard feedback that should be visible through the steering wheel's upper half. The left and right direction indicators control is made of a left/middle/right flip switch. The gears consist of a front/middle/back flip switch. Pushing the flip switch upwards activates forward gear and pushing it downwards activates reverse. Middle position means neutral gear and if pressed down in middle position, the parking brake takes over.

The scores of RULA and REBA (shown in Tables 1 and 2) were computed after implementing the said modifications in the simulated model generated using JACK- 8.0.1. The suggested changes have reduced the scores of RULA and REBA considerably thereby signifying a substantial decrease in the ergonomic risks involved in the proposed job. The advantages rendered by the proposed changes are decrease in the flexion of upper arms, wrist and shoulder and a tremendous decrease in the magnitude of the intermittent load acting on the arms while changing gears and taking a turn.

4 Conclusion

Prior to proposing modifications in the design of auto-rickshaws, a thorough investigation of the working postures of drivers has been carried out using ergonomic evaluation techniques of RULA and REBA. The final scores of both these methods indicate the same conclusion, that is, the drivers have a very high risk of developing a musculo-skeletal disorder and hence the working posture should be changed immediately. In the current study, an attempt has been made to lower the associated ergonomic risks by suggesting improvements in the design of driver's seat and handle-bar. Minor changes have been made in the dimensions of the seat by considering anthropometrics of the 50th percentile of the Indian male population. These changes will allow the driver to attain a comfortable and convenient posture while driving. Secondly, the traditional handle bar was replaced by a steering wheel which allows a more ergonomic posture. Buttons and flip switches have been

placed on the steering wheel for gear changing and activating different controls. These proposed changes were implemented in the simulated model generated using JACK 8.0.1 and at that juncture assessment of modified postures was carried out using RULA and REBA. The advantages rendered by the said modifications were clearly reflected in the scores that have been remarkably reduced. Hence, there is a tremendous scope for carrying out future research work in this field, the primary reason being the involvement of a large workforce who are extremely prone to occupational hazards.

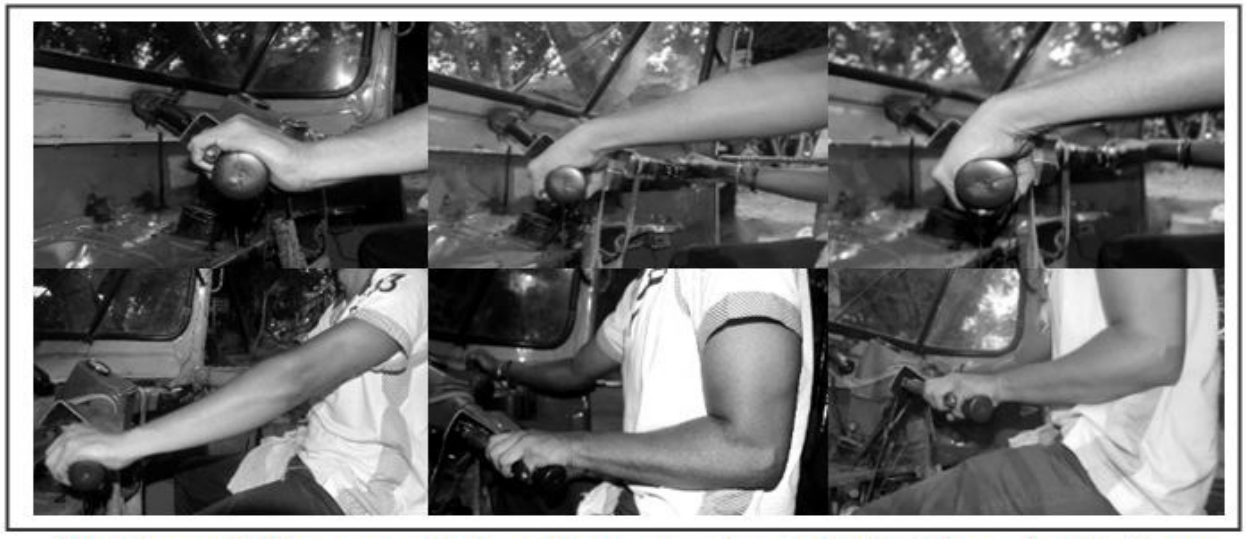

Fig. 1 Arm and Wrist postures during different gears; Row 1: 1st, 2nd. 3rd gear; Row 2: 4th gear and Turning

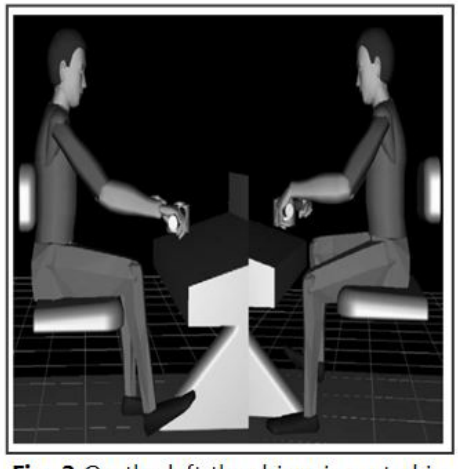

Fig. 2 On the left the driver is seated in a way that he utilizes the backrest, handlebars and brake pedal. On the right the driver is seated closer to the postures observed in Indian auto-rickshaw drivers.

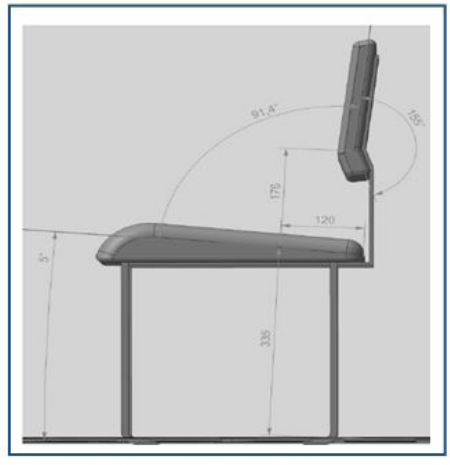

Fig. 3 The adjusted driver's seat

ISBN 978-93-5258-836-7

Table 4 Participation of elderly in various clubs and social activities

Parameters Studied	Group I 61 - 70yrs (n=61)		Group II 71 – 80yrs (n=47)		Group III >81yrs (n=23)		(Group I+II+ III)	(Group I+II +III)	Total
Gender	Females (n=27)	Males (n=34)	Females (n=17)	Males (n=30)	Females (n=14)	Males (n=9)	Females (n=58)	Males (n=73)	Total (n=131)
Organising	8	14	7	13	3	1	18	28	46
Bhajans	(29.6)	(41.2)	(41.2)	(43.3)	(21.4)	(11.1)	(31.0)	(38.4)	(35.1)
Social	8	9	3	7	1	1	12	17	29
Club	(29.6)	(26.5)	(17.6)	(23.3)	(7.1)	(11.1)	(21.0)	(23.3)	(22.1)
Gym	4	5	1	1	3	1	8	7	15
	(14.8)	(14.7)	(5.9)	(3.3)	(21.4)	(11.1)	(13.8)	(9.6)	(11.4)
Health club	2	5	1	5	1	0	4	10	14

Table 1 Descriptive statistics of the sample

Item	Classification	Percentage
Age group	18-30	50.59
	31-40	23.44
	41-50	18.33
	Above 50	7.64
Gender	Male	84.8
	Female	15.2
Experience	< 5 yrs	41.97

Table 2: Comparative scenario of improvement

System	Current layout	Proposed layout
1.No. of operators	9	10
2.No. of stations	10	11
3.Maximum cycle time	11.88 sec.	10.08 sec.
4. Line efficiency (%)	78.43	81.82
5. Balance delay (%)	21.57	18.18
6. Total distance of the line	5.9 m	5.3 m

References

1. Costa, A. R., Almeida, J., Figueiredo, J. P., & Ferreira, A. (2015). Ergonomic analysis—case study of passenger transport company. Occupational Safety and Hygiene III, 405.
2. Gangopadhyay, S., Dev, S., Das, T., Ghoshal, G., &Ara, T. (2012). An Ergonomics Study on the Prevalence of Musculoskeletal Disorders Among Indian Bus Conductors. International Journal of Occupational Safety and Ergonomics, 18(4), 521-530.
3. Hebbal, S. S., & Kumar, A. C. S. (2013). Ergonomic Risk Assessment using Postural Analysis Tools in a Bus Body Building Unit. Industrial Engineering Letters, 3(8), 10-20.
4. Hermanns, I., Raffler, N., Ellegast, R. P., Fischer, S., &Göres, B. (2008). Simultaneous field measuring method of vibration and body posture for assessment of seated occupational driving tasks. International Journal of Industrial Ergonomics, 38(3), 255-263.
5. Hignett, S., McAtamney, L., 2000. Rapid Entire Body Assessment (REBA). App. Ergo. 31, 201–205
6. Jagannath, M., Adalarasu, K., MuthuVignesh, V., &Sudheer, T. (2013). An ergonomic study on posture-related discomfort in backhoe-loader drivers. International Journal of Biomedical Engineering and Technology, 11(2), 155-168.
7. Lasota, A. M. (2015). Ergonomic Evaluation of Physical Risk for Packing Line Operators. Logistics and Transport, 26(2), 11-20.
8. McAtamney, L., Corlett, N.E., 1993. RULA: a survey method for the investigation of work-related upper limb disorders. App. Ergo. 24, 91–99
9. Rashid, H., Ma'arof, M. I. N., Omar, A. R., Abdullah, S. C., Ahmad, I. N., & Karim, S. A. (2014, April).Motorcyclist muscle fatigue index an effort to help reduce motorcycle accidents. In Contemporary Ergonomics and Human Factors 2014: Proceedings of the international conference on Ergonomics & Human Factors 2014, Southampton, UK, 7-10 April 2014 (p. 425). CRC Press.
10. Reiman, A., Pekkala, J., Väyrynen, S., Putkonen, A., &Forsman, M. (2014). Participatory Video-Assisted Evaluation of Truck Drivers' Work Outside Cab: Deliveries in Two Types of Transport. International Journal of Occupational Safety and Ergonomics, 20(3), 477-489.