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Tricycles for Nigerian Public Transport Unit: Assessment of Ergonomics Design Considerations

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ABSTRACT

Tricycles are becoming more popular commercial means of transport across all Nigerian cities. This study evaluated ergonomics status of this development. Measurement of seven variables comprising, seats' height, width and cushion inclination as well as space available for legs, back rest inclination, access/exit doors and circulation corridors, were carried out on the sampled Tricycle. The measured variables were compared with both the standard recommended for urban transport unit and the corresponding anthropometric data of users from Southwest and Eastern parts of Nigeria (SW/EN). Data were collected from 175 passengers through questionnaire to measure the degree of comfort/discomfort derived using the transit unit. Microsoft Office Excel 2007 was used for statistical analysis. About 59% of the total passengers reported discomfort using Tricycle. Among these, 26.6% complained of strains at hips/upper legs, 22.9% neck pains and 21.0% knees/lower legs. More than 23% of the affected attributed this to lack of space for legs' adjustment. All seats' dimensions deviated from the required standard. The z-test result also showed significant differences for 87.5% of the total measured in-element parameters when compared with corresponding 95th anthropometric data of users from SW/EN. The study showed that passengers using Tricycles are susceptible to injuries connected with awkward postures, vibrations and external contact stress. Improving design with the recommended standards for urban transport, as suggested by the finding, may help in overtaking these challenges.

Keywords: Tricycle; Passengers; Transportation; Discomforts; Ergonomics

INTRODUCTION

The work of Ngadiran et al. (2008) relating to the comfort and wellbeing of the drivers is a half of two lobes without a similar research focus on the passengers for safety of commercial road transportation. In Nigerian road transportation system, varieties of buses, taxis, omnibus, vans and motorcycles are used to move material and people from one place to the other (Onawumi & Lucas 2012). In his research on passengers' satisfactions with transport services in Nigeria, Ali (2014) noted high level of discomforts leading to lack of satisfactions of passengers with the available public transport services. Part of the causes reported for the users' discomforts are poor conditions of necessary facilities (Adejuyigbe & Adeyemi 2000). Some other ones are non-compliance of seat design to standards, long term confined postures and whole-body vibrations (Ajayeoba & Adekoya 2012; Durkin, et al. 2006).

In recent times, the use of paratransit (tricycle) is popular for transportation (Judith 2013). Obioma et al. (2012) stated that expansion of paratransit is gradually becoming a means of full public transport in some areas of the country due to poor public transport system and road network. Assessment of Tricycle operations revealed that emergence of various modes of transportation occasioned by the need to cope with socio economic trend and adverse economic situation of the country forced its operations and gave rise to its use (Mukhtar 2015). It was reported that because of its relative affordability and availability, some passengers in some areas of the country prefer using it (Sun 2009).

However studies have revealed that ergonomics consideration for users' comforts are not common in the design of the tricycles in the country. To minimise discomforts among public transport users, which should be paramount among other design considerations, there is need for proper assessment of seat design (Park et al. 1998), access and exit door/stairs (Miguel & Jesús 2004) among others. Seating should be properly designed to avoid backaches, strain, excess fatigue and extra stress on the neck and back. The inappropriate dimensions of steps and doorways cause in difficulty in accessing passengers' unit calls re-consideration of appropriate design (Okuribido et al. 2007).

Meanwhile, the use of anthropometric data in design constitutes improvement in the comfort derivable using the product. Physical dimensions of seats are specified using anthropometric data. Since the design of automobile

seat can affect, to a great extent, the posture of users, this approach to design can enhance both the comfort and physical conditions (Okuribido et al. 2007; Byrns et al. 2002). The anthropometric data of users therefore has its great roles in solving ergonomics problems (Farzana 2006; Barroso et al. 2005; Xiao et al. 2005). Thus, it must certainly apply in minimizing discomforts associated with Tricycle transportation systems.

In this work, effort is made to evaluate ergonomics status of using Tricycle as public transit units in Nigeria. This is with a view to determining the level of comfort and/or discomforts experienced by its users. The limit or extent to which the seat dimensions comply with the standard recommended and fit into anthropometric requirement of users in some regions of the country is also evaluated.

HYPOTHESES

1) H_0: There is no significant difference between Tricycle passengers' seat and the standards recommended for public transport unit.
2) H_0: There is no significant difference between some in-element measured parameters of the Tricycle and passengers' corresponding measured anthropometric.

MATERIALS AND METHODS

MEASUREMENTS OF SEAT VARIABLES

From preliminary investigation, one brand of Tricycles (TVS king) was found to be commonly used as transport unit in the study area (Ifo, Ifo Local Government, Ogun State, Nigeria). An observational study was carried out on the passengers' seats. Using trained personnel, the physical measurement of seven variables related to seat [cm], access and exit doors were carried out on twenty (20) sampled TVS king Tricycle. The measured values include: height of the seats, space available to accommodate the legs [cm], seats width [cm], back rest inclination [degrees], inclination of seat cushion [degrees], dimensions of the access and exit doors [cm] and dimensions of the circulation corridors [cm]. All inclinations were measured using a customized protractor device, which had an adjustable readout arm. Other measurements were carried out using a metre rule. The means measured variables were compared with the standard recommended for urban transport unit as well as the corresponding anthropometric data of users from Southwest and Eastern part of Nigeria.

Data relating to comforts and/or discomforts derived using Tricycle were collected from users (passengers) through the use of questionnaires which were filled out by interview after informed consent was obtained from each volunteer. Areas or regions of the body where they experience discomforts while on board were also asked to be indicated using a modified version of Nordic Questionnaire. Most of the questionnaires were filled out by the respondents themselves. The questions were read out to the illiterate users in native language (Yoruba). A total of 200 passengers (104 females and 96 males) were surveyed as equally used for related studies by Dike (2012). Microsoft Office Excel 2007 was used to determine the frequency distribution statistics and z-test to guide the decision to accept or reject the null hypothesis.

RESULTS AND DISCUSSION

QUESTIONNAIRE RETURN RATE

One hundred and seventy five (87.5%) of the two hundred passengers that participated in the study completed the questionnaire. All of them confirmed their frequent usage of Tricycle for transportation in not less than two years. The questionnaires' response rate is presented in Table 1.

TABLE 1. Questionnaires response rate

Description of sample	Sample size Sample size	Response rate	% of response
Male	96	81	84.3%
Female	104	94	90.38
Total	200	175	
% of Total	100%	87.5%	

RESPONSE TO QUESTIONS

Figure 1 shows passengers' responses to level of discomforts with the use of Tricycle. About 59% of the total participants reported discomforts any time they are conveyed in the sampled Tricycle. The highest percentage (26.6%) of the total respondents, among passengers who reported discomforts, indicated the pains at hips/upper legs. This is followed closely by 22.9% and 21.0% who indicted it at neck and knees/lower legs respectively. Other discomforts reported comprised of strains at lower back (17.1%), shoulders (5.6%), ankles/feet (3.7%), upper back (1.9%) and wrists /hands (1.1%).

Table 2 further revealed the opinions of passengers as regards using Tricycle. More than 23% of the total response attributed the discomforts experience any time in Tricycle to lack of space to adjust legs and 19.4% mentioned lack of facility for head rest as contributing to neck pains.

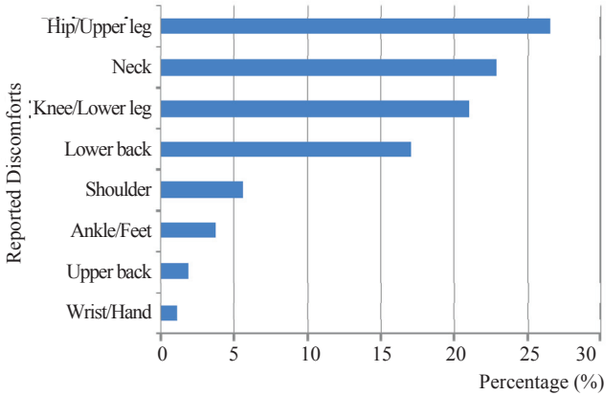

FIGURE 1. Passengers' responses to level of discomfort with the use of Tricycle

TABLE 2. Opinions of passengers regarding using Tricycle as means of transportation

Descriptions of Findings	Total Response	Percentage (%)
A. Self-opinion cause of reported pain:		
i. Seat not comfortable	44	10.4
ii. Vibration	61	14.5
iii. No space for legs adjustment	98	23.3
iv. No head rest	82	19.4
v. Unguided from fall/weather condition	53	12.7
vi. body rubs components	83	13.7
B. Board Tricycle because		
i. Cheaper	37	19.7
ii. beat traffic	85	45.9
iii. local availability	64	34.4
C. While in Tricycle, I always feel		
i. Proud	13	6.8
ii. In secured	73	39.5
iii. Happy	7	3.8
iv. Inferior	32	49.9
D. Preferred to Tricycle		
i. Bus	62	37.0
ii. Car	82	49.0
iii. Bike	23	14.0

While 14.5% complained of vibration, about 14% of the passengers complained of hitting their body parts against Tricycle body whenever the seat is fully occupied. Other similar complaints tendered included lack of provision for door safeguards from falling and inconvenient seats. Majority of the passengers (45.9%) mentioned that they board Tricycle because it can easily beat traffic jam notable in the part of the country as a result of bad road. Other reasons stated for using Tricycle include local availability and affordability.

However, majority (49%) reported that they prefer travelling in cars to other means of transportations because about 50% feel inferior while 39.5% feel unsafe using Tricycle. Apart from the above, the photographic data (plates 1 to 4) obtained from field study provides further support evidence for the above outcomes.

The conditions shown in Figures 2 and 3 are due to insufficient entrance space available for user's height and narrow space available at the entry. Similar to these observations are common among tricycle users which is suggested as one of the reasons for passengers' complaints of discomforts.

Figures 3 and 4 shows a condition where the space available for driver is shared by passengers. Those passengers sit uncomfortably with unnatural postures. The width of the driver's seat (30.5cm) is actually designed for one person. However to increase daily income, two people occupy the space leading to both the passenger and driver not being comfortable. It was also observed that there is no provision for hand support and so the passengers locate their hands at any available part of the tricycle for stability while their legs are almost outside. This exposes the passengers to road dangers. External contact stress could also occur because some parts of passengers' body are rubbed against component of the Tricycle, such as frame (as noted in Figure 4) and edge of the body (as observed in Figure 3). Nerves may be irritated resulting to pains in those regions of their body.

FIGURE 2. Showing a passenger in an extreme bending posture while entering the Tricycle

FIGURE 3. Showing awkward postures of user entering the Tricycle using his side

FIGURE 3. Showing the awkward sitting postures of a passenger holding on to roof horizontal supporting frames to keep himself in position and avoid falling out

FIGURE 4. Showing awkward sitting postures of a passenger holding on to vertical supporting frames to maintain stability and resist tendency to fall out

All the above findings are at variation with those reported by Dike (2012) where the respective ratios of the users of Tricycle, Taxi and Bus attributing convenience to these means of commercial transportation were 6.3: 5.8: 1.0 representing 48.2, 44.1 and 7.6% of respondents respectively. Meanwhile, the respective ratios that attributed comfort were 1.3 (31.2%): 1.9 (44.7%): 1.0 (24.1%). This implies that according to the passengers, Tricycle is the most convenient but second in comfort among the three transport units.

However, there appears to be agreement in regards to safety with those findings. The tricycle was rated the poorest in safety with the respective ratio of respondents reported as 1.0 (19.4%): 2.1 (41.2%): 2.0(39.4%). Similarly, the authors listed exposure to weather and high level of risk on the highway as part of the problems identified with tricycles. On the other hand, safety is identified as one of the reasons for the preference of tricycles among commuters (Jibrilla & Fashola 2017).

MEASURED PARAMETERS AND THEIR RECOMMENDED STANDARDS

Table 3 presents the dimensions of measured Tricycle seats, access and exit doors and the corresponding standard recommended for urban transport unit. It also displays the corresponding anthropometric data. This information is graphically presented in Figure 5.

TABLE 3. Data corresponding to the height of passengers' seats and their comparisons with the values recommended according to ergonomic criteria

	Tricycle Variables	Average Measured	Coresponding Dimension	Recommended		
				Max.	Min.	Ave.
A.	Height of the seats	40.7	Height of the seats	39.3*, **	Nil	39.3
B.	Space available to accommodate the legs [cm]	64.2	Glut - knee length	Nil	69.3*, 65.3**	67.3
C.	Seats width [cm]	37.2	Hip width	Nil	43.0*, 40.4**	41.7
D.	Dimensions of the access and exit doors [cm]	84.6	Shoulders width	Nil	55.3*, 52.6**	53.95
E.	Dimensions of the circulation corridors [cm]	48.9	Hip Width	Nil	43.0*, 40.4**	41.7
F.	Back rest Inclination [degrees]	104.3	Back rest inclination	Nil	110 - 130***	120
G.	Inclination of seat cushion	2	Seat cushion inclination	Nil	14- 24***	19

(Panero et al. 1991)*, (Márquez 1996)**, (Grandjean 1998)***, Max = Maximum, Min = Minimum, Ave = Average

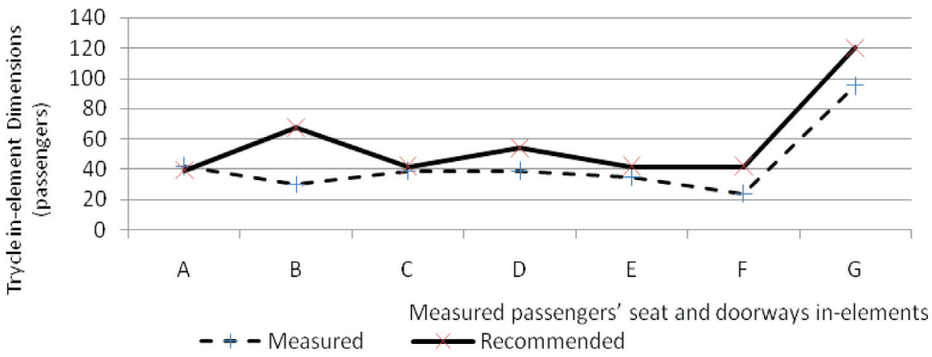

FIGURE 5. Comparing passengers' seat and doorways of the studied tricycle with the standard recommended for urban transport unit

TEST OF HYPOTHESIS 1

To compare statistically the standard recommended values for urban transport unit with the measured sampled tricycle passengers' seat values, the variance and z- testing was performed (Table 4). The null hypothesis is rejected if the result of the variance and z-testing indicates significance difference between the compared parameters. In that case, the obtained measured value need to be redesign to meet the standard recommended values. If result indicates otherwise, the null hypothesis is accepted implying that the measured parameters are well conformed to the recommended standards.

TABLE 4. Comparing Tricycle dimension measurements and standard recommended for urban transport unit

Tricycle Variables	Passengers' Side			
	Mtdm	Recom	Var.	Z-test
A	42	39.3	-2.7	Without
B	30	67.3	37.3	With
C	39	41.7	2.7	Without
D	39	53.95	14.95	With
E	35	41.7	6.7	With
F	24	41.7	17.7	With
G	95	120	25	With
H	2	19	17	With

MTDM = Mean Tricycle dimension measurements, RECOM = Recommended, VAR = Variation
Recommended in-element standards and previously obtained anthropometric data for users in South-Western and Eastern Nigerian.

The Z-test result shows that the "seat height (A)" and "seat width (C)", representing 25% of the total measured parts, may be considered closed to recommended standard. All other parts required modifications.

Table 5 shows the anthropometric data of potential Tricycle's users as obtained by two previous researchers in south-western (Ismaila et al. 2013) and Eastern part (Onuoha et al. 2012) of Nigeria.

According to Table 5, "Hip breadth sitting" for an average westerner is 37.7cm and 29.0 cm for an average easterner. The "seat width" of the tricycle is measured to be 114cm which is used to occupy three passengers without clearance between them. "Foot ramp" of the tricycle (40cm) which corresponds to "kneel height" of passenger (56.9 and 52.8) is 30% and 24% of lower height compared to the required dimension by an average passenger. This may therefore impose some level of discomforts to all categories of users. Seat height of tricycle dimension (42cm) corresponds to 'popliteal height' of anthropometric data. It is noted that this part of the tricycle can only be convenient for just few within 50th percentile of the population of users in South-western part and their corresponding counterpart in the Eastern part of the country. However 95th percentile of the users in any of the regions may be uncomfortable. "Leg clearance" of the tricycle (30cm) which is corresponding to "Buttock kneel length" (67.7 and 63.0 cm of the Westerner and Easterner respectively) is found to be 56% and 52% shorter than what is required by 95th percentile of the users. Majority of them may not be able to comfortably position their buttock kneel because of the shorter length. "Chair back rest height" of tricycle (43cm) corresponding to average "sitting shoulder height" of passenger (133.8cm) is about 68% shorter than what is required to ergonomically support the back of the passengers. This also may however cause some level of discomforts.

TEST OF HYPOTHESIS 2

The outcome of z-test on Table 5 reveals that only one, "seat height", of all other measured parameters, is significant in terms of similarity with the anthropometric values of the Western part which indicates that there is no difference between the measured and the anthropometric requirements. Hence the second null hypothesis is accepted for this and rejected for the rest. Statistical significance notwithstanding the dimensions of "roof height from seat" in the Tricycle are larger enough to accommodate the 95th percentile anthropometric data of the people of the area. "foot ramp", "seat depth", "leg clearance" and "backrest height" dimensions are however shorter than what is required by the users in the region.

TABLE 5. Comparing the Tricycle dimension measurements and passengers' anthropometric dimensions

Tricycle Dimen.	Western Nigeria				Eastern Nigeria			
	Ant.	Mtdm	Var.	Z-test	Ant.	Mtdm	Var.	Z-test
I	50*	40	10	With	56.6**	40	16.6	With
J	42*	36	6	With	53.5**	36	17.5	With
K	33*	39	-6	With	35.6**	39	-3.4	Without
L	40*	42	-2	Without	52.1**	42	10.1	With
M	77.5*	100	-22.5	With	92.9**	100	-7.1	With
N	None	79	None	N/A	91.8**	79	12.8	With
O	56*	30	26	With	63**	30	33	With
P	55*	43	12	With	57.7**	43	14.7	With

(Ismaila et al. 2013) * (Onuoha et al. 2012) **, ANT = Anthropometric, MTDM = Mean Tricycle dimension measurements, VAR = Variation, I = Foot Ramp, J = Seat Depth, K = Seat Width, L = Seat Height, M = Roof Height from seat, N = Hand support, O= Leg clearance, P = Backrest Height

On the users at the Eastern side, only "seat width" is significant. However this group of users will still be able to use "roof height from seat" component because the measured value is larger than what the passenger required. Every other parts will however need some level of redesign so that the groups of people will be comfortable using it.

CONCLUSION

This study evaluated ergonomics status of Tricycles used for commercial transport across all Nigerian cities. Majority of the passengers involved in the study reported discomforts getting on the Tricycle. Out of these responses, strains at hips/upper legs, neck pains and knees/lower legs were mentioned. The disorders were attributed to lack of space to adjust legs and the facility for head rest. Average passengers reported they felt inferior and unsafe using Tricycles. Others mentioned that they only used Tricycle because it was available, affordable and could easily beat traffic jam during congestions. All seats measured deviated from the required standard dimensions recommended for public transport unit. "Seat cushion inclination" has the highest percentage of deviation followed by "Space available to accommodate the legs". All seats dimensions required modifications with suitable adjustments in the affected body dimensions except "seat height" which indicated no significant difference when compared with 95th percentile of anthropometric data of users from Southwest and Eastern parts of Nigeria. From the study, deviation of current design from the recommendation for transport unit makes users of Tricycles susceptible to injuries connected with awkward postures, vibrations and external contact stress.

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