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Ergonomics assessment of locally fabricated passenger seats in trotro vehicles in Accra, Ghana

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ABSTRACT

Trotro vehicles constitute one of the major means of transportation in Ghana by way of ferrying people and goods. Most trotros are originally brought into the country as load carrying vehicles, which are then converted into passenger vehicles. Locally designed seats are then fabricated and secured into the vehicles. The study explored the ergonomic evaluation of the locally fabricated passenger seats with anthropometric measures of passengers and also compared the seat dimensions to required standards. The study was undertaken at seven selected bus stations in Accra, the capital city of Ghana. The study composed of 307 volunteer passengers comprising 175 females and 132 males with ages spanning from 18 to 60 years. The dimensions of ninety locally fabricated seats were collected from ninety randomly selected trotro vehicles. Ergonomic assessment was performed to determine match or mismatch between the anthropometric measures and vehicle seating dimensions. In addition, the fabricated seat dimensions were compared to both local and international vehicle seat standards. High mismatches indicating that the passenger seats were probably too deep or too high were observed for seat height – popliteal height, seat depth – buttock popliteal length, and seat breadth – hip breadth. A low mismatch was observed between the sitting height and backrest height for 99.4% of participants. Only four and ten out of the ninety seats complied with specified standard seat length and backrest to backrest distance, respectively. The high prevalence of mismatch is a possible indication that most locally fabricated seats do not adequately accommodate majority of passengers. Furthermore, it appears that anthropometric measures and standard vehicle seat dimensions are not considered during seat design, with potential health ramifications pertaining to the safety, comfort and sitting posture of passengers.

1. Introduction

Trotros are privately-owned multipurpose commercial minibuses used in the informal mass transportation system in Ghana (Fouracre et al., 1996). Similar buses being used in Nigeria are popularly referred to as Tokunbo (Ismaila et al., 2010). The term trotro originates from “tro” meaning three pence in reference to the fares charged in the past in a local Ghanaian dialect. Trotro serves

Abbreviations: AMVCB, Australian Motor Vehicle Certification Board; BMI, Body mass index; BPL, Buttock Popliteal length; BRH, Backrest height; BRW, Backrest Width; ISO, International Standard Organization; LI, Legislative Instrument; LTO, MVIS - Land Transportation Office Motor Vehicle Inspection system; PH, Popliteal Height; PNS, Philippine National Standards; SB, Seat Breadth; SD, Standard Deviation; SdA, Seat Depth; SH, Seat Height; SHa, Sitting Height; SPSS, Statistical Program for Social Sciences.

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Fig. 1. Locally fabricated seats and interior view of the trotro vehicle.

as one of the major and preferred means of commercial transport in Ghana (Abane, 1993, 2011) and accounts for almost 70.0% of the means of transportation in Accra according to the World Bank's consultative citizens report card for the city of Accra (World Bank, 2010). Most minibuses have designated routes they ply, along which they can stop to allow passengers to board and alight. Sometimes, they veer into other non-designated routes to find passengers to board their vehicles. The trotro vehicle is operated by a driver and a conductor usually referred to as the "mate". The driver controls the operation and movement of the trotro from one stop to the next, whilst the mate collects the fares, publicises to attract passengers, as well as mediate between the driver and passengers.

The vans used for trotro are imported into the country either as second-hand or new and most are originally manufactured as load carrying vehicles, which are later modified into commercial passenger vehicles. As part of the redesigning into passenger vehicles, seats are locally fabricated and installed, as well as incorporation of new features such as side windows to enhance ventilation and lighting. Some of the local automotive artisans or technicians who design and fabricate trotro seats have little or no formal vocational training in automotive seat designing, but rather informal apprenticeship. It appears that most trotro seats are designed without considering any approved or standard dimensions. Also, most artisans do not incorporate any engineering design concepts or principles during vehicle alterations (Amedorme and Agbezudor, 2013). Some artisans design the seats to suit the vehicle owners' specifications or dimensions specified by the drivers' unions. Interestingly, little attention may be given to the comfort and safety of passengers, as the design and fabrication are undertaken not according to any known accepted safety standards (Dzebre, 2012; Dzebre et al., 2013). The local manufacturers assume that design of seats is an art rather than science (Ismaila et al., 2010). One of the primary goals of these artisans is to derive optimum number of seats for profit maximisation by the vehicle owners (Agyemang, 2013; Ismaila et al., 2010; Saba et al., 2013). Usually, seating capacities in trotros can range from about 10 to 25 and may consist of about 3 to 5 rows of seats with each row having a seating capacity of about 3 to 5. Some of the rear right seats are foldable to enhance movement of passengers during boarding and alighting as shown in Fig. 1. Most locally fabricated seats are bench seats supported by metallic frames and upholstered.

Trotro seats constitutes a major component of the vehicle occupant protection system and their design must comply with both local and international standards to ameliorate the effects of crash-related injury severity. The essence of standards is to decrease the rates of deaths and injuries to motor vehicle users (Federal Motor Vehicle Safety Standards and Regulations, 2015). The use of anthropometric data in design may constitute improvement in the health and comfort of the users (Barroso et al., 2005; Jung and Lee, 2000). The aim of seat design is to alleviate or decrease factors that pose discomfort rather than to elicit feelings of well-being (Reed et al., 1994). In Ghana, vehicle reconstruction or modification is regulated by the Road Traffic Regulation, Legislative Instrument, 2012 (L.I. 2180), which also provides the required seat dimensions. Elsewhere, the Australian Motor Vehicle Certification Board (AMVCB) provides vehicle standards for the manufacture and installation of seats (National Code of Practice, 2013). In Hong Kong, Guide for Measuring of Passenger Seats is provided as part of the regulation of standards (Guide for Measuring Passengers on Public Light Bus, 2004). Similarly in India, automotive industry standards are available as part of the code of practice for bus body design (Automotive Industry Standards, 2014).

In order to consider seat ergonomics, there is the need to determine seat fit parameters for anthropometry. Therefore, there is the need to investigate the match or mismatch between the passenger seats and the general population anthropometry. Various studies have reported varying degrees of incompatibility between anthropometric data and local vehicle seating dimensions. A study conducted in Ibadan Metropolis, Nigeria, which compared relevant anthropometric measurements obtained from 200 passengers with mean age of 37.9 years to dimensions of locally manufactured seats obtained from 30 randomly selected Toyota Hiace minibuses, established a mismatch between anthropometric and passenger seat dimensions (Ismaila et al., 2010). It was observed that significant differences existed between the means of popliteal height and seat height; buttocks to popliteal length and seat depth; and hip breadth and seat width. Similarly, a study undertaken in Malaysia sought to determine the degree of compatibility of seat fit parameters by comparing the anthropometric dimensions of 216 participants to two local automobile seats (Daruis et al., 2011). Mismatches were observed between the anthropometric dimensional variables which are important for seat fit parameters and dimensions of the two seats. In addition, both seats were too long to fit the 5th percentile female driver, as well as too high for the 5th percentile woman and yet not high enough for the 95th percentile man. To buttress the aforementioned studies, when locally manufactured passenger seat dimensions from 30 minibuses were compared to 144 anthropometric dimensions of passengers around

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