Comfort Analysis of Commercial Motorcyclists Using Protective Helmets Operating in Ogbomoso, Oyo State Nigeria

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Abstract: Wearing Personal protection gear primarily for safety is a basic requirement in riding two-wheel vehicles with Helmet being the most important of them. The continuing avoidance of the use of helmet among Nigerian motorcycle riders calls for investigative studies on its user friendliness and sustainability. This study investigates the effect of available makes of helmet on riders' comfort, safety and attitude towards the use of the protective gear in the study area. Five nodal points were identified for testing of temperature change with time of riding business and the effect on performance and riding behaviour. Riders' awareness of safety rule and level of compliance were investigated. Unavailability of adequate variety of helmet and attitudinal challenges were observed to have significant effect on the safety and performance of business riders of motorcycle in Nigeria. Development of effective anthropometry database was suggested for the design and production adequate

Key word: Personal protective gear, comfort, nodal points, heat, attitude

I. INTRODUCTION (*HEADING 1*)

Human head has been identified as the most delicate and highly exposed part of human body Consequently vivid efforts were made by research into the area of motorcycle accident and specifically on the effectiveness of helmets in some developed countries (Lawrence *et al*. 2002, Liu *et al*. 2008). The impact of such research was reflected in the quality standard established for design of helmets. The possibility of cyclist involved in auto-crash to be killed is higher compared with operators of other road vehicles. Unlike in advanced countries where standards were developed most of the income countries have little or no legislation on the operation and safety of motorcycles (EEVC, 1993). Protective wears prescribed for safety of motorcycle riders includes helmet, motorcycle jacket, gloves, pants, boots or other heavy boots. Helmet remains the most important head gear that any cyclist is expected to wear Motor-cycles are one of the most popular transportation modes in Nigeria. The total number of registered motorcycles in Nigeria was 31.11 % of the total stock of registered vehicles in the year 2005 and the number keeps increasing every year. Also motorcycles were found to account for one out of every four vehicles involved in crashes in Nigeria. (Arosanyin *et al* 2012). The comfort of motorcyclists has not drawn much public attention in Nigeria until a few years ago, when the frequency of motorcycles' accident became high. Helmet design that would be acceptable by large percentile user population remain a serious challenge as a result of so many factors that require attention and particular consideration such as the anthropometrics of head which determines the shape, size and style of the helmet, safety and comfort demand of individual users and other work related psychosocial factors. The market situation particularly in the U.S. where there are mandatory helmet laws depict that helmets comes in large varieties with divergent variation in protective/comfort attributes which create much task in search, choice and availability of fitting helmet. It has been

reported that wearing helmets reduces air-flow around the head and leads to an increase in heat-related stress as a result of the temperature distribution between the head and helmet liner (Pang, *et al* 2011). This internal heat generated between the head and helmet liner results in a state of discomfort for the rider. Poor quality helmet often exposes the rider to motorcycle related head injury when there is a fatal accident (Lee *et al* 2010, NHSTA, 1996). There is a popular resentment of cyclist and commuters to wearing of helmet in low income countries because of its perceived negative effect on riders' security and performance (Muhamad, 2011). With the increasing economic and cost of injury record relating to motorcycle riding worldwide, a study comfort of cyclist using helmet will be highly needful considering the ineffectiveness of mandatory helmet laws in Nigeria.

A. Nigerian Motorcyclist and Challenged Attitude to wearing of Helmet

While it is widely accepted that use of helmet is essential when riding motorcycle to prevent head injury and fatality due to motorcycle crash, the attitude of riders towards this safety practice is still far from expectation and highly discouraging particularly in Nigeria. A study of motorcycle crash characteristics in Lagos Nigeria by Oni et al (2011) revealed only 12.4 % of the motorcyclist use helmet while driving and Ogunmodede et al (2012) found that 33 % of riders of motorcycles in Oyo state used crash helmet while a study conducted on riders in the north-central of Nigeria informed that none of the motorcyclist used crash helmet (Nwadiaro et al, 2011). Onawumi and Oyawale (2016) and Akinlade and Brieger, (2004) recognised the contributions of Federal Road Safety Commission (FRSC) of Nigeria in the enforcement of road worthiness of motorcycle and safety rules and regulation on motorist in Nigeria. Still the disgusting feeling of riders to use of crash helmet call for further psychosocial study of the rider's attitude towards this safety requirement. Likewise, the incessant and almost generally poor attitude suggest implicitly that user comfort must have been challenged by the available crash helmet.

B. Human Physiology and Helmet Design

The skin covering head has several veins and arteries having sensitive functions which are to be performed at specific body and environmental conditions. Specific among the arteries and veins under the cover of helmet are Pariental emissary vein, zygomaticoobital artery, frontal branch of supervisial temporal artery and vein, parental branch of supervisial temoporal artery and vein, supraorbital artery and vein and supratrochelear artery and vein. (Merriam-Webster, 2016).

Human skull is an important, complex and very sensitive part of human skeletal system. It is a bony structure consisting of twenty-two bone arranged into eight cranial bones and fourteen facial bones which among many other functions provide needed protection for human brain in other to prevent injury, protect and support the sense organs resident in the head region, store calcium and regulate the endocrine. Human brain regulates and controls volume of human activities including the control of central and peripheral nervous systems. The temperature for human body temperature is regulated by hypothalamus in the brain with its limit at 2.05^{o}C. A serious hazard that a motorcycle rider is susceptible to when accident occur is head injury which affects the brain and if fatal may lead to brain damage or death. Susceptibility of human head to head injury has been found to vary with sex and age with men being more prone to the hazard than women. The effectiveness of helmet to protect wearer from injury is called to question when its material, shape and other design qualities fail to match human musculoskeletal requirements. This may have been a reason for non-compliance of motor cycle riders with road traffic law relating to wearing of helmet is a strong tendency among motor cycle riders.

In this study the response of riders to heat induced by the helmet and resulting physical and psychological changes it introduced were investigated using commercial motorcyclists in Ogbomoso Southwestern Nigeria as subject The temperature distributions on the head of the rider and body temperature of the motorcycle rider were obtained and analyzed. The helmets design for specific user population in a particular geographical location could make a lot of difference which affects the effectiveness, reliability and comfortability of the safety wear.

The effect of heat on the head has been studied by researchers and was found to be adverse on people exposed to the scourge of the heat for a long time. The head temperature increases exponentially in response to the long exposure to fixed afternoon temperature. Human body effectively regulate temperature to maximum of 36.81 ^{O}C even as the ambient temperature increased to 42 ^{O}C which lay credence to human warm bloodedness. The homoeothermic nature could have ceased in the case of rider wearing helmet as he operates the with the vehicle in the scourge of heat form sunlight.

II. Materials and Method

Two prominent models of helmets used in Ogbomoso Southwestern Nigeria (Skyo Serpent and JC Yoli Helmets) were considered for this study. Calibrated data-logging five channels temperature measuring device was used to measure the temperature changes with each channel attached to each of the five nodal points on the head of the test subject as presented in Table 1. Helmet was securely fixed on the subject's head with the probes on and the meter firmly stuck to the waist while the subject is engaged with the ridding of the motorcycle. Data were obtained in triplicate to obtain the representative values for temperature (^{o}C) and duration (minute) gradient at varying hour of the work day. The subject used in this study was certified to be healthy and do not surfer from and any known medical

challenge. Thermal responses of the subject were taken for each of the helmet separately and analysed.

The temperature of the motor-cyclist was taken and recorded at every interval of 30 minutes for a cycle of 180 minutes. The body temperature of the motor-cyclist was taken before the start of the experiment and further measured at 30minutes interval along with the measurement of the subject's head temperature. Student t-test of paired samples was used to compare difference between nodal /sensor locations after 30 minutes of conducting the experiment at significant level, $\alpha = 0.05$. The subjects whose means of livelihood is business riding of motorcycle was informed of the study and with his consent was dressed up in the study attire typical of his usual day job wears with helmet and the data logged five-channel temperature measuring devise. The instrument has removable data storage card (memory card) where recorded data were store and save appropriately for further analysis. Each subject wore a helmet at a time in order to keep separate record of human responses to heat. The study was carried out between the hours of 12noon and 3:00pm. A time when heat from the sunshine reached its peak.

Table 1: Nodal Description of Test Subject

Nodes	Description of Location on Human Skull (Merriam-Webster)	
	Bone	Muscle
1	Occipital bone	Occipitalis
2	Sphenoid bone	Temporalis
3	Parietal bone	Cranial aponeurosis
4	Frontal bone	Frontalis
5	Temporal bone	Temporalis

Figure 1: The Measurement of Temperature Distribution on Motorcyclist Head.

III. Results and Discursion

The variation of heat on subject's head having the helmet on with time while carrying out normal day job for a duration of 2hr 20minutes (between the hour of 12:00 and 14:30) with the probes placed on each of the segments on the skull is present in figure 2. The temperature of the heat produced on the wearer of skyo serpent is consistently higher than that of JC Yoli in all the five points where the channels were located. This suggests significant level of discomfort as the temperature reached 41.9 ^{o}C, The variation of temperature with location is also revealing for each of the helmet used by the rider. The temperature at parietal bone (upper rear of the skull) increases at highest rate for both make of helmet considered.

A. Average Head Temperature Variations

The temperature on the head of motor-cyclist with the two helmets firmly secured increases progressively as the working time of operation increases and on average the temperature for the two helmets investigated increased between 0.1 – 0.4 ^{o}C for Skyo Serpent above JC Yoli Helmet. Normal body temperature of healthy adult ranges between 36.5 and 37.5 degree C. A wider range of normal temperature as reveled in literature is 33.2 – 38.2 ^{o}C. The head temperature variation on the average range between 36.3 – 42.37 and 38.1 – 41.1 for riders wearing Skyo Serpent and JC Yoli respectively (figure 2f). This is indicative of the pressure placed on hypothalamus and possible consequential increase in brain temperature with minimum and maximum differences for wearer of Skyo Serpent and JC Yoli (3.1, 4.17) and (2.9, 3.9) degrees C respectively. Though helmets are observed to constitute unsafe condition JC Yoli shows a near acceptable range hence making it preferable to Skyo Serpent helmet. The obvious implication is the irrational and irritable behaviour of riders exposed to excessive scourge of heat from sunlight as brain may fail to effectively regulate certain human behavioural activity.

The result of interview conducted on the motorcyclists using the two common helmets informed that the subjects using Skyo Serpent Helmet which typically lacked internal foam padding experienced high degree of discomfort when compared with users of JC Yoli Helmet which has internal foam padding with other accessories. This implies more discomfort is experienced by the user of Skyo serpent which could result in fatal accident experience resulting from the significantly high temperature stresses. Body temperature of the commercial motorcyclist increases as work duration increases. The body temperature when the rider was covered with Skyo Serpent is higher than JC Yoli helmet. The selected helmets, one (JC Yoli) represent the full faced type and the other (Skyo Serpent) represent half covered type. JC Yoli covers whole head leaving only the eyes area open, while the Skyo Serpent cover only the skull leaving the eye, nose, ear and mouth open.

B. Average Head Modelling

The resulting heat produced on the skull of the subject wearing Skyo serpent and JC Yoli helmets were used to develop a model as shown in figures 3 and 4 respectively. The models gave a relationship between the temperature on the skull and duration of operation of motorcycle with $(R_{skyo})^2 = 0.9962$. and $(R_{JC})^2 = 0{,}9988$.

The models are presented in equations 1 and 2:

$$T_{skyo} = -0.0001t^2 + 0.0496t + 37.38 \quad (1)$$

$$T_{JC\ Yoli} = -0.0002t^2 + 0.0535t + 36.852 \quad (2)$$

Where: T = Temperature in degree C and t = Duration in minutes.

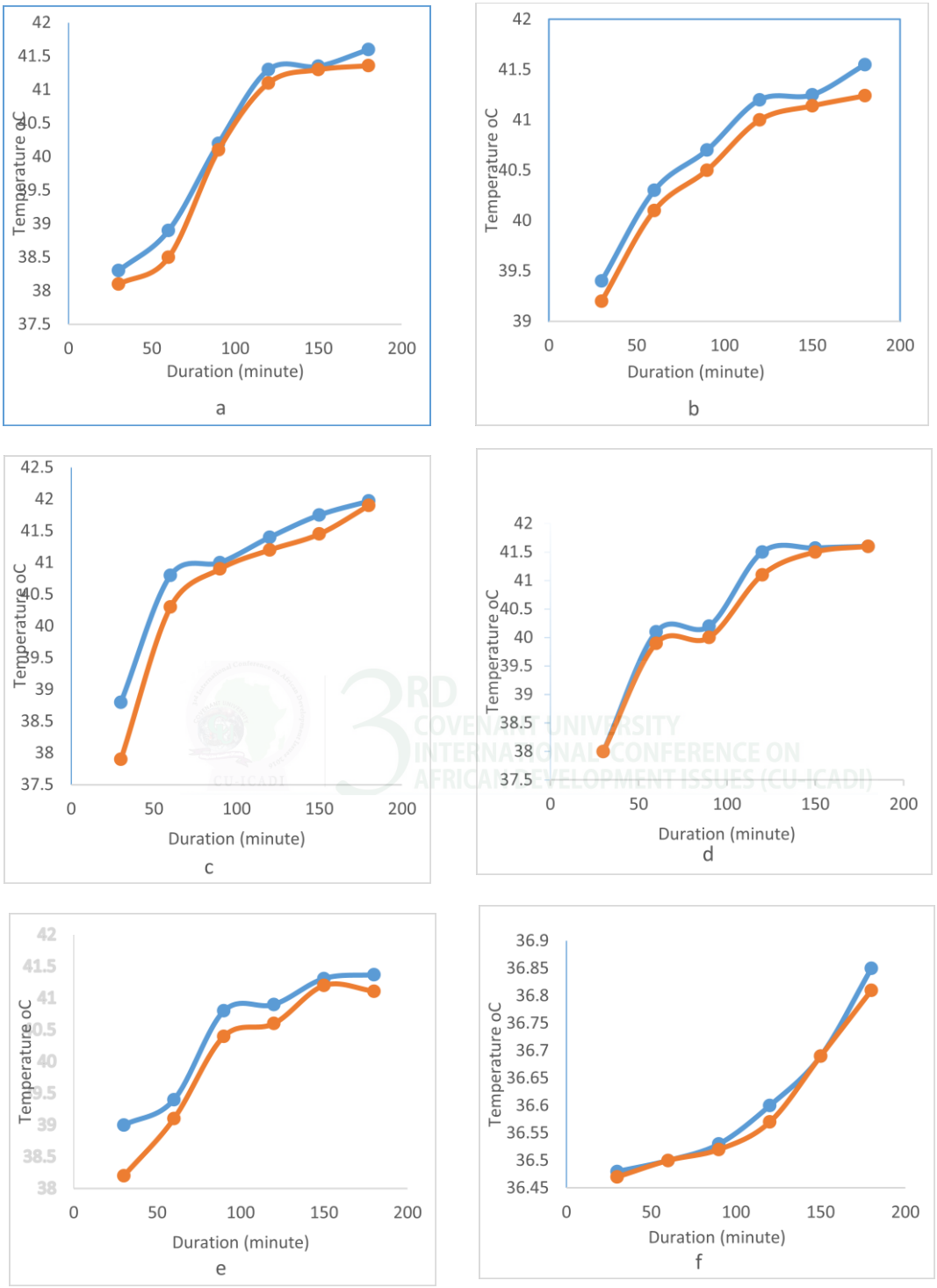

Figure 2: Skull Temperature of Motor-cyclist wearing Skyo Serpent and JC Yoli Helmet with probe located on a: Occipital bone, b: Sphenoid bone. c: Parietal bone d: Frontal bone e: Temporal bone, f: Body

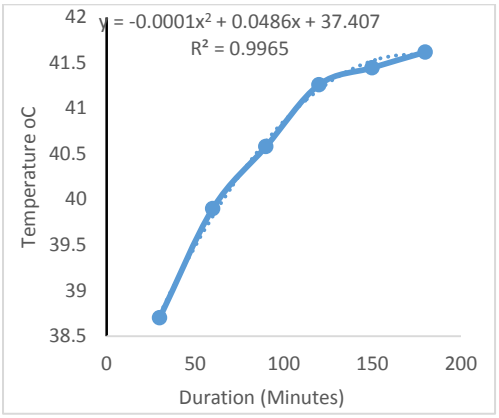

Figure 3: Average Skull Temperature of Motorcyclist wearing Skyo Serpent

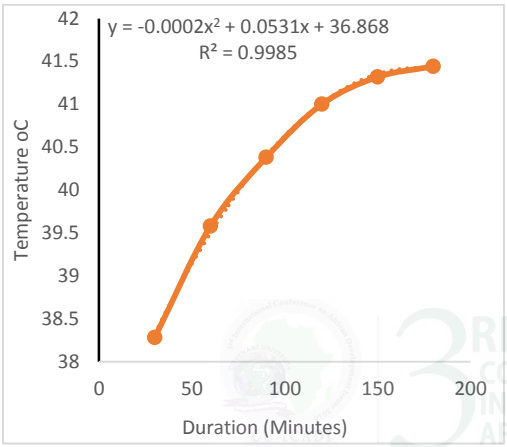

Figure 4: Average Skull Temperature of Motorcyclist wearing JC Yoli Helmets

IV. Conclusions

The degree of discomfort experienced by motor-cyclists differs and largely depends on the type of helmets used and the working hours. With the five channels temperature device equipped with the selected helmets, on average, the head temperature increased between 0.1 – 0.4 ^{o}C for Skyo Serpent above JC Yoli Helmet. This increment pose a danger on the comfort of motor-cyclist, as it can leads to high degree of discomfort for the rider.

Recommendation

The need for design of safer and ergonomically suitable helmet for cyclist in equatorial and tropical region of Nigeria becomes inevitable as the existing helmets have failed to provide sufficient vents that could reduce accumulation of heat which consequently lead to the irritable feelings of the users. Continuous education of motorcyclists on safety issues and licensing of riders for the categories of either public or private use of motorcycle to enhance correct attitude towards the use of helmet.

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