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Effect of Road Transport Stress on the Cardiorespiratory Parameters of Young Adult Nigerians During the Harmattan Season

Kolawole Victor Olorunshola, Lydia .N. Achie and Ogunwole Eunice
Department of Human Physiology, Faculty of Medicine, Ahmadu Bello University, Zaria, Nigeria

Abstract: The effect of road transportation covering a distance of 160km over a period of 90 minutes on cardiopulmonary parameters and body temperature of 26 healthy young Nigerians was studied during the month of January 2011 during the harmattan season in Zaria. There were statistically significant diurnal variations in the metereolodical datae during the study period ($p<0.001$). Similarly, there was a statistically significant increase in the serum level of cortisol from 0.57±0.45μmol/L before to 1.05μmol/L after transportation ($p<0.001$). Diastolic blood pressure, Mean Arterial Blood Pressure (MABP) and body temperature were elevated after transportation, though not significantly. There were no significant differences in the mean blood glucose, pulse pressure, pulse rate and peak expiratory flow rate before and after road transportation ($p>0.05$). We conclude that though the road transportation was stressful, the various homeostatic mechanisms were able to control the altered parameters within normal ranges.

Key words: Blood pressure, body temperature, expiratory flow rate, harmattan season, peak, respiratory rate, road transport, stress.

INTRODUCTION

Transportation is an essential part of human activity and in many ways form the basis of all socio-economic interactions. There are considerable evidences that transport related pollution contributes to short-term and long-term increases in ill-health and mortality including cardiovascular and respiratory diseases (WHO, 2003; Krzyzanowski *et al*., 2005). The extent to which people are exposed to air pollutants depends on many factors such as being inside a vehicle, working or living close to traffic, physical activity level, duration of exposure, and stage of life, health status, how, where and how often they travel.

It has been reported that fetuses, children, the elderly and those with pre-existing breathing and heart problems are vulnerable to the effects of road-traffic-related pollution (Buringh *et al*., 2002). Studies have found an association with vehicular emissions and a diversity of respiratory symptoms and diseases like coughing, wheezing, asthma and Chronic Obstructive Pulmonary Disease (COPD) (Sunyer *et al*., 1997; Ciccone *et al*., 1998; Peters *et al*., 2000; and Sarnat and Holquin, 2007). Cardiovascular diseases such as Acute Myocardial Infarction (AMI), cerebrovascular accident (stroke), high blood pressure and coronary heart diseases are epidemiologically linked to exposure to particulate matters and emission from daily vehicle transportation (Peters *et al.*, 2000; Brooke *et al*., 2002; Finkelstein *et al*., 2005; Jerrett *et al.*, 2005; Kunzli *et al*., 2000; Gehring *et al*., 2002).

In veterinary practice, studies have shown that transportation of animals by road constitute a major source of stress to the animals as evidenced by increase in the serum level of cortisol, creatinine kinase, lactate dehydrogenase and a decrease in leukocyte count, plasma albumin, β-hydroxylbutyrate, plasma glucose, reduced fibrinogen concentration, changes in level of β endorphin, free iodothyronine and serum testosterone levels (Knowles *et al*.,1994, 1999a,b; Ruiz-De-La-Torre *et al*., 2001; Hickey *et al*., 2003; Broom *et al* 1996., Broom, 2005; Earley and O'Riordan, 2006; Luigi *et al*., 2007; Buckham-Sporer *et al*., 2008).

Stress induced changes in lower animal are affected by factors such as nature of road, quantity of gas emission, loading distance and duration of journey, vibration of vehicle, environmental temperature, season and space availability between the animals (Piccione *et al*., 2005; Peterson *et al.*, 2006; Voslarova *et al*., 2007; Minka and Ayo, 2007, 2008). There are three (3) distinct seasons in the guinea savannah region of Northern Nigeria. They are the Harmattan (November - February) which is also known as the cold and dry season, hot dry (March-May) and hot-humid or rainy season (June -

Corresponding Author: Dr. Kolawole Victor Olorunshola, Department of Human Physiology, Faculty of Medicine, Ahmadu Bello University, Zaria, Nigeria

October), (Igono and Aliu, 1982). The thermal aspects of the environment during these seasons are stressful with the harmattan being thermally more stressful to lower animals (Igono *et al*., 1983; Minka and Ayo, 2007, 2008; Ayo *et al*., 1999).

In humans, there are several neuro-endocrine homeostatic mechanisms to regulate the effect of stress and changes in cardiopulmonary system. There are no literatures on the evaluation of the direct effect of road transport stress on the cardiopulmonary system in humans. Road ambulances are used to evacuate trauma victims from sites of injury and from one health facility to another. The contributions of transportation stress to the medical conditions of patients being evacuated with ambulances have not been previously studied. In Australia, the Northern Territory Road Transport Fatigue Management Board set up a code of practice for road transport operators to ensure they meet their duty of care obligations for the provision of a safe and healthy working environment. This is lacking in many developing nations.

The study was aimed at investigating the effects of road transport stress on Mean Arterial Blood Pressure (MABP) pulse pressure, pulse rate, Peak expiratory flow rate and body temperature of healthy young adult Nigerians.

METHODOLOGY

Study site: The study was conducted in Zaria, Kaduna state, Nigeria in the month of January 2011 during the harmattan period. Zaria lies in the Savannah belt, latitude 11º3′ N, longitude 7º42′ E with a mean annual temperature of 27ºC. The monthly temperature is highly variable, varying between 15.6º and 32.1º in the different seasons (Ati, 2004; Mortimore, 1970).

Meteorological data of the study area: The Dry-bulb Temperature (DBT) and Relative Humidity (R.H) were measured using a wet and dry bulb thermometer (Ellab Inc. USA) at the experimental site at 6.00, 14.00 and 18.00 h daily for three consecutive days before and after transportation. The sunshine duration and wind direction were also recorded.

Study population: Twenty six healthy adult volunteers (17 males, 9 female) between the ages of 20-35years (mean age 24.8±0.56) were recruited into the study. Exclusion criteria included smoking, alcohol consumption, hypertension, diabetic mellitus, obesity, musculo-skeletal disorders, sickle cell disease and goiter. Written informed consent was obtained from each volunteer before the commencement of study and approval from the Ethical Committee on Human Research of Ahmadu Bello University, Zaria was obtained.

Vehicle design and transportation: A standard Toyota Coaster 32 seater bus (Toyota, Japan) was used for transporting the subjects. The body of the vehicle was made of steel and the floor of steel covered with a rug carpet. The inner compartment of the vehicle measured 15.5×4.8 m. The side walls of the body of the vehicle to a height of 2.8 m was made of steel sheets above which were 6 windows of 1.2×0.8 m dimension on each side for ventilation. The steel roof was lined by foam and upholstery leather. Boarding the car was by a swinging door which had a windscreen on the right hand side of the car. Each subject was on a seat and the whole group accompanied by three research assistants. No artificial air cooling was used and the subjects sat facing the direction of movement of the vehicle.

Transportation of the subjects was conducted from the faculty of medicine complex on the main campus of Ahmadu Bello University, Zaria (11º3′ N and 7º42′ E) to Mando, Kaduna (11º10′ N and 7º38′ E) and back to Zaria nonstop. They covered a distance of 180km at a speed of 65-75 km/h over a period of 2 h.

Collection of data: Subjects were fasted for 10 hours before the commencement of study. Basal blood pressure, pulse rate, Peak Expiratory Flow Rate, (PEFR), core body temperature (oral), body weight, height and the body mass index were noted and recorded before commencement of the trip. All the parameters were re-assessed after the trip except for the weight and height of the subjects.

The weights of the subjects were measured while wearing light clothing to the nearest 0.2 kg with a calibrated scale. Height (without shoes) was measured to the nearest 0.5 cm with a standiometer. The body mass index was calculated as weight (kg)/ height (m^2), (Guyton and Hall, 2006). Core body temperature was determined using a digital thermometer (Hangzhou Sejoy Electronics & Instruments Co., China) placed sublingually for 2-3 min and the temperature measured in degrees centigrade orally before the reading was noted and recorded for each subject.

Blood pressure measurements were obtained using a sphygmomanometer (Accosson, London) and a Littmann stethoscope (3M Health Care, USA). The inflatable cuff of the sphygmomanometer was wrapped round the upper arm of the subject. The brachial artery was occluded by inflating above the systolic pressure and gradually deflated till pulsatile blood flow was re-established. The accompanied sounds detected (first Korotkoff sound and point of disappearance of the sounds) correspond with the systolic and diastolic pressures respectively (Pickering *et al*., 2005). The measurement was done with the subject seated. Mean arterial blood pressure for each subject was calculated as MABP = Diastole BP + 1/3 Pulse Pressure. Arterial pulsation from the radial artery was palpated and counted in one minute for each subject before and after the trip.

With the subjects standing, the maximum flow generated during expiration performed with maximal force after a full inspiration was noted on the Wrights' Peak Flow Meter. Two readings were recorded and the mean value calculated and recorded as mL/L (Miller *et al*., 2005).

Blood collection: With the aid of a tourniquet tied around the upper arm, the cubittal fossa was cleaned with a swab of methylated spirit and venous blood was collected. Subjects underwent blood sampling before and immediately after the trip using 5 mL syringes and 21G needles. 2 mL of the blood was transferred into EDTA bottles for determination of blood glucose level using a glucometer. While 3 mL was transferred into clean dry test tubes and centrifuged using a bench centrifuge at 1,500 rpm for 15 min. The serum was collected using a Pasteur pipette and stored in a freezer at -4ºC for cortisol assay.

Determination of blood glucose level: Blood glucose concentration for each subject was determined using a rapid glucometer (ACCU-CHEK Meter Systems, USA) based on the glucose oxidase method as described by Yuen and Mc-Neil (2000). A small drop of blood from each specimen collected before and after transportation was placed on a disposable test strip and inserted in the glucometer which displayed the blood glucose concentration in mmol/L.

Determination of serum cortisol level: The assay for serum cortisol was carried out using BLK Cortisol Enzyme Immunoassay Kit (BLK diagnostics, France). According to the manufacturer's instruction as described by Dhar *et al*. (1986) and Candito *et al.* (1992). Absorbance at 450 nm was determined by a microplate reader and cortisol concentration was determined using the standard curve. This was carried out at the Department of Chemical Pathology, Ahmadu Bello University Teaching Hospital (ABUTH), Shika, Zaria.

Statistical analysis: Results obtained were recorded as mean±SEM and analyzed using Students t test with a p value of <0.05 considered statistically significant.

RESULTS

The mean ambient temperatures, relative humidity, sunshine and rainfall during the harmattan season of year 2011 are presented in Table 1. The mean ambient temperature in the study site ranged from 10.9±0.12 to 28.3±0.21ºC with a mean of 19.6±0.20ºC corresponding to a diurnal cycle of cold nights alternating with warm days. The relative humidity ranged from 16 to 22% with a mean of 18.0±0.43% during the the study period. Duration of sunshine was shorter (mean of 8.2±0.25 hours/day). The wind during harmattan was cold, dry and dusty and there was no rainfall.

Table 1: Mean±SEM for meteorological data during the study.

Ambient	Temperature (ºC)
Minimum Ambient Temperature (ºC)	10.9±0.12
Maximum Ambient Temperature (ºC)	28.3±0.21
Mean Ambient Temperature (ºC)	19.6±0.20
Relative Humidity (%)	18.0±0.43
Sunshine (h/day)	8.2±0.25
Rainfall (mm)	
Amount	0.00
Days	0.00

Data collected from Meteorological Unit, Institute of Agricultural, Research, Ahmadu Bello University, Zaria; during the 2010/2011 harmattan season

Table 2: Cardiopulmonary parameters, Serum glucose, Serum cortisol and body temperature of the subjects before and after transportation

Parameters	Before (Mean±SEM)	After (Mean±SEM)
Systolic Blood Pressure (SBP) mmHg	118.4±2.9	117.9±3.36
Diastolic Blood Pressure (DBP) mmHg	79.5±1.72	80.6±2.27
Pulse Pressure mmHg	38.9±2.18	37.7±2.85
Mean Arterial Blood Pressure (MABP) mmHg	92.2±1.91	93.2±2.31
Pulse Rate (Beat/Minutes)	83.27±2.94	78.69±2.86
Peak Expiratory Flow Rate (PEFR) L/min	393.15±13.49	380.77±13.35
Body Temperature (ºC)	36.72±0.17	36.74±13.35
Serum Glucose (mmol/L)	3.25±0.65	3.08±0.70
Serum Cortisol Level (μmol/L)	0.57±0.45	1.05±0.49**

**: p<0.001

Mean serum cortisol level significantly increased from 0.57±0.45 before transportation to 1.05±0.49 μmol/L after transportation (p<0.001), but there was no significant change in the serum glucose concentration before and after transportation, (Table 2). Though the systolic blood pressure, pulse pressure, pulse rate and peak expiratory flow rate recorded after transportation were lower than values before transportation, the differences were however not statistically significant (p>0.05). Similarly, the diastolic blood pressure, Mean Arterial Blood Pressure (MABP) and body temperature were elevated after transportation, the values were not significantly different from values obtained before transportation (p>0.05), (Table 2).

Peak Expiratory Flow Rate (PEFR) showed a significant sex difference, for example, the PEFR of 426.5±14.30 and 417.1±11.72 L/min in the male subject before and after transportation, respectively were significantly higher than PEFR of 330.2±10.64 and

Table 3: Sex difference in cardiopulmonary parameters before and after transportation

	Before transportation		After transportation	
Parameters	Male (n =17)	Female (n = 9)	Male (n = 17)	Female (n = 9)
BMI (kg/m^2)	23.4±0.64	23.6±1.20	-	-
SBP (mmHg)	120.7±3.37	114.0±5.42	120.8±4.33	112.4±5.00
DBP (mmHg)	81.8±1.90	75.1±3.08	80.6±3.19	80.7±2.79
MABP (mmHg)	94.5±2.16	87.8±3.4	94.2±3.12	91.3±3.29
Pulse pressure (mmHg)	39.3±2.59	38.2±4.20	40.8±3.79	31.8±3.50
Pulse rate (beats/min)	84.1±3.87	81.8±4.62	79.4±4.28	73.3±3.50
PEFR (L/min)	426.5±14.30*	330.2±10.64	417.1±11.72*	312.2±13.64
Body temperature (ºC)	36.8±0.19	36.5±0.35	36.7±0.09	36.8±0.11

*: p<0.05; Showing a significant increase in the PEFR of the male subject as compared to the female subjects (p<0.05)

312.2±13.64 L/min obtained in the female subjects before and after transportation respectively ($p<0.05$) (Table 3). There were no significant sex differences in the systolic blood pressure, diastolic blood pressure, MABP, pulse pressure and rate and body temperature before and after transportation ($p>0.05$).

DISCUSSION

From the result obtained, transportation of the young adults for 160 km over a period of 1.5 h during the harmattan season was stressful to the subject as indicated by the significant rise in serum cortisol level from 0.57±0.45 to1.05±0.49 μmol/L ($p<0.001$) after the journey. There was however no significant change in the serum blood glucos level during the study, (Table 2).

Though the journey was stressful, there was no significant alteration in the studied cardiopulmonary parameters viz. blood pressure, peak expiratory flow rate and body temperature. The diastolic blood pressure, mean arterial blood pressure and body temperatures were mildly elevated after the road transportation in our subjects. Arterial baroreceptors have homeostatic mechanisms capable of regulating mild to moderate change in the mean arterial blood pressure, having rapid action, starting less than one second and are quite powerful reflexes. They play very significant role to prevent changes in venous return, cardiac output and arterial pressure Barrette *et al*., 2010). Brooke *et al.* (2002) reported that chronic exposure to particulate matters can lead to systemic inflammation thereby accelerating atherosclerosis with altered cardiac and autonomic functions with heart rate variation and raised blood pressure. In our study, the subjects were only exposed for a duration of about 90 min and a distance of about 160 km.

There was no significant change in the body temperature of the subject before and after transportation. Ayo and Oladele (1996) reported a significant increase in body temperature of pullet transported over a distance by road. Piccione *et al.* (2005), documented thermal stress during diurnal road transportation of young ostriches. Similarly, Voslarova *et al.* (2007) reported a significantly high mortality among hens and roosters transported to poultry processing plants which was related to the transport distance and season of the year.

The hypothalamus contains thermo-receptors which controls other parts of the brain to regulate the body temperature through heat production or heat loss. It does this by controlling blood flow through causing sweating, shivering, secretion of cathecolamines and thyroid hormones (Barrette *et al*., 2010).

The PEFR in these subjects was also not altered by road transportation over a period of 1.5 h. The distance and duration of road transportation here were both short. There will be need to investigate the PEFR in longstanding commercial drivers who are chronically exposed to stress, particulate matter and fumes. The sex difference observed in PEFR agrees with established fact of stronger, respiratory muscle in males.

Novelty to transportation may provoke fear stress in animals. Our subjects were all university students who are already used to travelling on the road hence the stability in the cardiopulmonary parameters despite the significant increase in serum cortisol level.

CONCLUSION

From the result of this study, it appears that road transport stress over a short distance and shorter duration has little deleterious effec on cardiopulmonary functions and body temperature of normotensive humans. This is due to effective homeostatic mechanisms in humans as opposed to what is obtainable in lower animals. Further studies on hypertensive and normotensive individuals during other seasons (rainy/wet and dry/hot) and over a longer distance and duration are recommended.

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