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TREKKING AS AN ALTERNATIVE INTRA CAMPUS TRANSPORTATION MODE AMONGST UNIVERSITY STUDENTS: THE ERGONOMIC CONCERN

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Abstract
Trekking is an old means of transportation, as old as mankind. Its replacement with other modern means (beast of burdens, bicycle, tricycle, cars, trains, ships, aircraft, etc) is due to the quest to gain speed, reduce stress on humans at some reasonable associated cost. The use of combustion engines to propel the vehicles to motion and sustain the motion throughout the journey requires fuel. These fuels are often fossil based source, which are very expensive and hazardous to humans and the environment. Aside from environmental factors, the hike in the intra campus transportation fare resulting from the recent hike in fuel pump prices in Nigeria has made students consider trekking as alternative means of transportation. The paper attempts to analyze the physiological cost of work and the relative aerobic strain on a student who decides to trek within school. The trekking time was relatively low (23.14±1.65 minutes) for the 1.58km distance from the gate to the department of Industrial and production engineering. The Aerobic Strain on all participants engaged in walking, irrespective of the period (morning, afternoon or evening session), gender and age, was less than 35% of their maximum aerobic capacity, and that of the jogging exercise was slightly higher (52.81±7.26). More so, the participants expend an average of 647.7±10.30 KJ per journey, which translates to about 154.95 Kcal. The research concludes that trekking as an alternative means of intra campus transportation is physiologically safe for the students, irrespective of gender, age and period of the day.
Keywords: *Fossil fuel, Human factor engineering, Multivariate Analysis, Climate Change, Health Safety and Environment.*

Introduction

Since the advent of the industrial revolution, pollution in air, water, and land, has consistently increased. This is due to increase in mechanization, which is heavily powered by fossil fuel, whose byproduct is harmful to life. Transportation is a major contributor to the rise in pollution. As people and goods are conveyed from one point to another, pollution occurs. Wei et al. (2007) reported that exposure to tricycle fumes poses significant health risks to various populations in Nigeria. For instance, Alexander et al, (2017) pointed out that within Kano metropolis, CO2 emissions from transportation revealed that 15.75 metric tonnes per hour were released from cars and buses, 6.08 from tricycles and 0.56 from lorries. According to the report an hourly emission of 22.39 tonnes was recorded.

According to Mbachu et al. (2022), the environmental effect of using fossil fuel powered engines has not deterred students from its use, and the article noted that economic impact is a stronger influence on student decisions. Interestingly, the recent hike in the cost of Premium Motor Spirit (PMS) and Automotive Gas Oil (AGO) has pushed the cost of transportation to an unbearable height, especially for students. Prior to this hike, the students used tricycle (also known as keke) and shuttle buses as means of transportation within the campus, but now some students have resorted to the use of bicycles, and many others to trekking. The current alternatives are obviously more economical and environmentally friendly. What then is the physiological cost on the students who opt for trekking as an alternative? What factors influence the cost? And what is the level of strain on the students? These are very important questions whose answers will determine the usability of that option as a means of transportation.

Sadly, Odunlami et al. (2018) revealed alarmingly high CO concentrations, which exceeded recommended standards, on five out of six sampling routes in Port Harcourt. The highest average reached 42.5ppm on Ikwerri Road, significantly exceeding limits. Even after adjusting for longer averaging periods, several locations still showed concerning levels. Four years later, Eyankware and Ulakpa (2022) is still making similar claims and calling for intervention. Eyankware & Ulakpa (2022) in addressing these environmental and health concerns suggested the following: Stricter Emission Standards coupled with regular inspections and maintenance enforcement; adoption of cleaner fuels and technologies - liquefied petroleum gas (LPG) and promoting electric tricycles; and public awareness about the health and environmental risks associated with tricycle fumes. Hubacek et al. (2007) on the other hand, had earlier suggested the adoption of alternative transportation options, such as bicycles and public transit.

Based on a preliminary survey conducted on the subscription of students to the use of tricycles as a means of transport, there is about 52% drop in patronage due to the current hike in transportation fare, occasioned by the recent increase in fuel pump fares. This aligns with the submission of Mbachu et al. (2022) that students react more to economic effects than to the environmental impacts of alternatives. The students by trekking to and fro the department will be saving three hundred naira daily, and approximately forty two thousand naira per session which is about their tuition fee per session as of the time the survey was conducted.

Beyond economic and environmental considerations, the health, safety, and comfort of the users are important factors in the design of any product, process, or system. Ergonomics is the practice that takes into consideration the human factors in design, with the goal of fitting man to the job and the job to the man towards the achievement of better system efficiency. Several researches have been carried out in this regard. These include: Godwin and Okpala (2013) - ergonomic assessment of musculoskeletal disorders from load lifting activities in building construction; Jazani and Mousavi (2014) - impacts of ergonomics on quality, considering the five areas of ergonomics (hardware, environmental, software, work design, and macro ergonomics; Mbachu and Okonkwo 2018 - A physiological Assessment and Analysis of Stairs Climbing: Using the RAS and Efficiency of work done. According to Schiffert Health Center (2010), physiologic fatigue is the predominant form of fatigue among college student, and is attributed to overwork, lack of sleep, or a defined physical stress such as pregnancy. The report noted that healthy students with excessive or minimal exercise regimens also experience fatigue.

As the curricular activities at the university increase, students tend to have less time for extracurricular activities like exercise, games, etc. Trekking, as a means of intra campus transportation, is expected to provide such an opportunity to the students. Albeit, there is a need to appraise the work, to ensure it is not strenuous, unduly heavy, or detrimental to the students' wellbeing.

Material and Method

A total of twenty-one (seven male and fourteen female) normal, healthy adults (with no history of chronic pain, major injury, or surgery to the lower limbs or back) participated in the study. They were within the age bracket of 18–24 years (mean = 20.95, SD = 1.97), and the mean mass is 68.5 kg (SD = 10.79), respectively. The heartbeat rates of the participants were measured before and after the exercise with pulse oximeter and the duration taken to finish the task was measured using a stopwatch. The participants (majorly 300 level students of Industrial and production Engineering) were given orientation before embarking on the task. The distance covered during the task is 1.58km, measuring from the department to school's exit gate (known as the Ifite gate). The work rate varied slightly between 1.013 m/s to 1.386 m/s.

Computational Analysis and Synthesis

The relative aerobic strain is given by;

$$\mathrm{RAS} = (\mathrm{HBRWORK} - \mathrm{HBRREST})/(\mathrm{HBRMAX} - \mathrm{HBRREST}) \qquad (1)$$

Where,

$HBRWORK$ = $heart\ beat\ rate\ while\ work$ing $or\ immediately\ after\ work$
$HBRREST$ = $heart\ beat\ rate\ before\ work\ or\ at\ resting\ position$
$HBRmax$ = $maximum\ expected\ heart\ beat\ rate\ which\ is\ a\ function\ of\ age.$

For the purpose of this work, the $HBRmax$model adopted from the Karvonen formula was used as shown below;

$$\mathrm{HBRMAX} = 220 - \text{age of the participant} \qquad (2)$$

Using equations 1 and 2 above and the values of the $HBRRESTandHBRwork$measured during the experiment the RAS were computed and shown in the table 1;

The $\eth VO_2$ for the samples and the corresponding physiological cost of work in joules are then derived using Bar-Haim et al (2008) experiment based model in equations 3a and 3b:

$$\eth VO_2 = 252 + (7.14 * \eth HBR) + (14.37 * wt) \qquad (3a)$$

$$\text{Physiological cost of work} = \eth VO_2 \left(\frac{ml}{min}\right) * \left(\frac{L}{1000ml}\right) * \text{worktime (min)} * 5\left(\frac{Kcal}{L}\right) * 4186\left(\frac{J}{Kcal}\right) \qquad (3b)$$

The LINEST tool alongside with the TINV tool in Excel is used to run the multivariate analysis and to determine level of significance of factors that determined the dependent variables – RAS, the physiological cost of work.

Results

The raw data obtained via measurement and observations are presented in table 1b. This include: sex, mass, age, HBR rest/ before work, HBR at work, start and finish time of journey, and total distance covered. The following factors are coded as shown in table 1a.

Table 1a: codes for selected factors

Codes	**1**	**2**	**3**
Sex	Male	female	
Activity	Walking	jogging	
time of work	morning	afternoon	Evening

Table 1b: observed and measured data for all participants

Students	Sex	Age (yrs)	Body mass (kg)	Time left	Time returned	Heart rate (start)	Heart rate (stop)	Activity	time of work
1	2	20	62	9:34am	9:56am	69	87	1	1
1	2	20	62	7:06am	7:28am	114	155	2	1
1	2	20	62	3:12pm	3:37pm	77	102	1	2
1	2	20	62	1:30pm	1:49pm	85	99	1	2
2	2	18	50	9:34am	9:58am	78	101	1	1
2	2	18	50	3:17pm	3:40pm	76	92	1	2
2	2	18	50	4:27pm	4:51pm	81	87	1	3
2	2	18	50	1:30pm	1:56pm	80	95	1	2
3	2	23	78	9:34am	9:59am	85	120	1	1
3	2	23	78	3:15pm	3:39pm	69	88	1	2
3	2	23	78	4:27pm	4:48pm	72	85	1	3
3	2	23	78	1:30pm	1:52pm	88	98	1	2
4	1	19	85	7:06am	7:30am	75	148	2	1
5	2	21	72	3:14pm	3:38pm	57	74	1	2
6	1	22	71	3:15pm	3:38pm	82	98	1	2
7	1	24	73	3:14pm	3:38pm	56	74	1	2
8	2	20	75	3:14pm	3:39pm	53	119	1	2
9	1	23	76	4:27pm	4:50pm	82	85	1	3
10	1	22	74	4:27pm	4:48pm	84	90	1	3
11	1	20	66	4:27pm	4:50pm	75	96	1	3
12	1	22	68	4:27pm	4:49pm	74	88	1	3

From the obtained data, most of the participants are females, within the age bracket of 20.81 ± 1.97 and body mass of 68.5 ± 10.79 kg. Most of the exercises were performed in the afternoon. The average heart rate before and after work are 78.1 ± 11.75 beats/minutes and 99.3 ± 20.88 beats/minutes. The relative aerobic strain and the physiological cost on each participant were computed using equation 1 and 4b as shown in table 2

Table 2: computed values of RAS and the physiological cost of work for all participant

Participants	Ras (%)	Physiological cost of work (Kj)
1	13.74	579.9
1	47.67	654.8
1	20.33	684.8
1	12.17	489.5
2	18.55	564.5
2	12.7	517. 2
2	4.96	504.2
2	12.3	580.8
3	31.25	870.8
3	14.84	779.1
3	10.4	663.1
3	9.17	684.9
4	57.94	992.4
5	11.97	700.5
6	13.79	661.1
7	12.86	711.2
8	30.77	822.4
9	2.61	651.1
10	5.26	591.3
11	16.8	643.84
12	11.29	606.16

From table 2, it was observed that the Relative Aerobic Strain (RAS) was below 35 for all participants not minding the time (morning, afternoon, or evening session). This shows that less than 35% of the maximum aerobic capacity was utilized for the work. It then suggests that the exercise is safe for all participants. Those participants engaged in jogging over the same distance, completed the task faster but at a higher RAS of 47.67 and 57.94 – participants 1 and 4. Jogging falls within the safe activities using only 47.67% and 57.94% of the maximum aerobic capacity. Concerning the energy expended, the participants expended an average of 647.7 ± 10.30 KJ per journey, which translates to 154.95 Kcal. Hence, apart from the economic and environmental gains, this will serve as a good exercise for the students.

Does this result vary with the activity (walking or jogging), velocity of the journey, cardiovascular condition of the participant before work (heart rate before trekking), the body mass of the students, the age, or gender of the student? These answers were obtained from multivariate analysis using LINEST tool in Excel as shown in table 3a and 3b. The significance of these factors in determining the values of the candidate's RAS and physiological cost was obtained by comparing the calculated T value (Ci/Sei) and the table value of T at 0.05 and corresponding degree of freedom (14). Ci is the coefficient of the factor in the regression model developed, and Sei is the associated standard error of the factor.

Table 3a: Result of regression analysis for the selected variables and the dependent variable - physiological cost of work

	Activity (x_1)	**Velocity (M/S) (x_2)**	**Time of the Day (x_3)**	**Heart Rate (Start) (x_4)**	**Body mass (Kg) (x_5)**	**Age (Yrs) (x_6)**	**Gender (x_7)**
C_i	161220.80	-373440.73	-7153.47	-31.82	9414.05	8813.46	65965.77
Se_i	69520.06	159013.44	24277.81	1482.14	2373.26	11421.75	31811.82
R^2, Se_v	0.9945	61056.49	#N/A	#N/A	#N/A	#N/A	#N/A
F, df	364.94	14	#N/A	#N/A	#N/A	#N/A	#N/A
SS_{reg}, SS_{resid}	9.5233E+12	52190531915	#N/A	#N/A	#N/A	#N/A	#N/A
F(DIST)	9.5535E-15						
$t_{computed}$	2.3191	-2.3485	-0.2947	-0.0215	3.9667	0.7716	2.0736
t table value (0.05,14)	2.1448	2.1448	2.1448	2.1448	2.1448	2.1448	2.1448
Abs($t_{computed}$) – $t_{(table\ value)}$	0.1743	0.2037	-1.8501	-2.1233	1.8219	-1.3731	-0.0712
Implication	**Significant**	**Significant**			**Significant**		

From table 3a, it was deduced that the selected factors has linear relationship with the physiological cost of work (PSW) as shown in equation 4a. The coefficient of determination was as high as 99.45. The equation, based on the coefficient of each factor, shows that PCW increases as the activity moves from walking to jogging; as the body mass increases; as age increases; and as the gender changes from male to female. It reduces as: velocity increases; the time of the day changes from morning to evening; and the heart beat rate before work increases.

$$y_{PCWi} = 161220.80x_1 - 373440.73x_2 - 7153.47x_3 - 31.82x_4 + 9414.05x_5 + 8813.46x_6 + 65965.77x_7 \qquad (4a)$$

Three factors were found to be significant – the activity, velocity and body mass. Those with higher body mass tend to expend more energy while trekking, and at higher velocity more energy is expended. The result also suggested the obvious – more energy is expended during jogging than when walking.

Table 3b: Result of regression analysis for the selected variables and the dependent variable - RAS

	Activity (x_1)	**Velocity (M/S) (x_2)**	**Time of the Day (x_3)**	**Heart Rate (Start) (x_4)**	**Body mass (Kg) (x_5)**	**Age (Yrs) (x_6)**	**Gender (x_7)**
C_i	0.2656	-0.1678	-0.0502	0.0014	0.0051	-0.0147	0.0190
Se_i	0.0635	0.1452	0.0222	0.0014	0.0022	0.0104	0.0290
R^2, Se_v	0.9579	0.0557	#N/A	#N/A	#N/A	#N/A	#N/A
F, df	45.5356	14	#N/A	#N/A	#N/A	#N/A	#N/A
SS_{reg}, SS_{resid}	0.9905	0.0435	#N/A	#N/A	#N/A	#N/A	#N/A
F(DIST)	1.4378E-08						
$t_{computed}$	4.1843	-1.1559	-2.2659	1.0060	2.3748	-1.4108	0.6541
$t_{\text{table value}}$ (0.05,14)	2.1448	2.1448	2.1448	2.1448	2.1448	2.1448	2.1448
Abs($t_{computed}$) – t($_{\text{table value}}$)	2.0396	-0.9889	0.1211	-1.1388	0.2300	-0.7340	-1.4907
Implication	**Significant**		**Significant**		**Significant**		

From table 3b, it was deduced that the selected factors has a linear relationship with the relative aerobic strain (RAS) as shown in equation 4b, with a coefficient of determination as high as 95.79. The equation, based on the coefficient of each factor, shows that RAS increases as: the activity moves from walking to jogging; the body mass increases; the heart beat rate before work increases; and as the gender changes from male to female. It then reduces as: velocity increases; the time of the day changes from morning to evening; the age increases.

$$y_{RASi} = 0.2656x_1 - 0.1678x_2 - 0.0502x_3 + 0.0014x_4 + 0.0051x_5 - 0.0147x_6 + 0.0190\,x_7 \qquad (4b)$$

These three factors were found to be significant – the activity, time of the day and body mass. From equation 4b, those with higher body mass tend to experience higher relative aerobic strain. The RAS on the participants was found higher when the exercise was performed in the morning and lowest in the evening. Also, the result suggested that the participants experience more relative aerobic strain while jogging than during walking exercise. From the two analyses, age and gender do not have a significant influence on the RAS and PSW. Hence, since the exercise has been found safe, it is safe for all within the considered age bracket, irrespective of the gender of the student.

Conclusion

Interestingly, the research has shown that trekking as an alternative means of intra campus transportation is not just economical, environmentally friendly, but physiologically safe for the students, irrespective of gender and age. The trekking time was relatively low (23.14 ± 1.65 minutes) for the 1.58km distance from the gate to the department, in this case Industrial and production engineering. It was observed that the Relative Aerobic Strain (RAS) was below 35 for all participants not minding the time (morning, afternoon or evening session), i.e. less than 35% of the maximum aerobic capacity was utilized for the work. There was a slight increase in the RAS for jogging activity (47.67 and 57.94), which is still within the safe limits. More so, the participants expend an average of 647.7 ± 10.30 KJ per journey, which translates to about 154.95Kcal. Hence, apart from the economic and environmental gains, trekking will serve as a good exercise for the students.

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