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Cardiorespiratory Response to Exercise Among Undergraduate Students of Ghana and Nigeria

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ABSTRACT

The purpose of this study was to compare dynamic aerobic cardiorespiratory response to exercise among undergraduate students of the Department of Sports and Exercise Medical Sciences, University of Health and Allied Sciences, Ghana and undergraduate students of the Department of Human Kinetics and Health Education of University of Calabar, Nigeria. Ex-post facto research design was adopted for the study. The Population consisted of undergraduate students of Ghana and Nigeria totalling 85 students. Simple random sampling technique was applied to select 50 participants (25 students from each country comprising 15 males and 10 females) for the study. Standardized instrument was used for data collection. The variables compared were Resting Heart Rate, Exercise heart Rate and Maximal Oxygen Consumption (VO2max). Data collected were subjected to descriptive and inferential statistics, where Independent t – test was applied to test for Hypotheses. The level of significance was set at .05 with 48 degree-of-freedom. The findings of the study revealed no significance differences in all the variables compared among the students of both Departments from both Countries, as a result the null hypotheses were rejected. It was concluded that the students from both Departments of the two different Countries in a related area of discipline exhibited good cardiorespiratory health and aerobic fitness as these are good indicator of physiological fitness for them to undertake their course in both Sports & Exercise Medical Sciences and Human Kinetics both in theory and in practice.

Keywords: Cardiorespiratory endurance; Exercises; Undergraduate students; Resting Heart Rate; Maximal Oxygen Consumption.

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INTRODUCTION

Physiologically, the body responds to exercise as a stressor in different ways. Exercise increases metabolic rate of the body for the purpose of enhancing physical fitness. However, with exercise, there are increases in metabolic rate, heart rate, blood flow (hyperaemia), respiration, and heat production. The increased metabolic requirement during exercise is well met by an increased blood flow (functional hyperaemia) and oxygen supply to the exercising tissue, which is regulated by multiple local and systemic mechanisms (Xiang & Hester, 2018). According to Nobrega et al, (2014), the body movement during exercise requires activation and control of the musculoskeletal system; the cardiovascular and respiratory systems provide the ability to sustain this movement over extended periods.

During exercise, the muscles need more oxygen in order to contract and they produce more carbon dioxides as a waste product (Akameze & Ajibola, 2017). Therefore, the cardiorespiratory system works together to get oxygen to the working muscles and remove

carbon dioxide from the body. The cardiorespiratory system responds predictably to the increased demands of exercise. Apart from few exceptions, the cardiovascular response to exercise is directly proportional to the skeletal muscle oxygen demands for any given rate of work, and oxygen uptake ($VO_{2\ max}$) increases linearly with increasing rates of work (Matthews & Fox, 2009; Turley, 2012). Most of the cardiorespiratory effects of exercise are related to supplying adequate oxygen and nutrients to the working muscles. This task becomes more difficult when the exercise is performed in a hot environment (Rowell, 2006).

Exercise stress is also used clinically to evaluate and quantify the severity of cardiovascular and/or respiratory disease (Patel & Zwibel, 2020). One of the two general types of exercise is dynamic aerobic exercise that include walking, running, cycling and swimming. Dynamic exercise produces striking burden on the cardiorespiratory system of any of the various stresses the body encounters in normal active life (Mark, 2014). In dynamic exercise there is a relationship between oxygen consumption and exercise intensity and also the maximal amount of oxygen an individual consumes (Gaesser & Brooks, 2004).

Understanding how the circulatory and respiratory systems respond and interact in respect to exercise is very essential in Sports and Exercise Medical Sciences. In addition, having taught a course in the department where the students took part in dynamic aerobic exercise of running, the authors therefore became interested in the maximal oxygen consumption among the male and female students in respect to the cardiorespiratory response to dynamic exercise intensity and recovery.

Generally, exercise has a positive cardiorespiratory effect on athletes or active people than sedentary individuals (Akameze & Ajibola, 2017). No two individuals are the same in their reception of and reaction to conditions. Therefore, male and female individuals engaging in regular aerobic exercise could exhibit different forms of cardiorespiratory responses (Turley, 2012). Studies have been conducted on cardiorespiratory responses to exercise and recovery among undergraduate students of Sports and Exercise Science in other Universities in other countries such as the University of Punjab India; and University of Calabar, Nigeria but none has been conducted in University of Health and Allied Sciences, Ghana.

The present study has been conducted with the aim to compare the exercise and recovery patterns on cardiovascular variables such as Resting Heart Rate before and after exercise following maximal exercise among undergraduate students in Ghana and their counterparts in Nigeria. Specifically, the study was designed to: ascertain the difference in Resting heart rate between undergraduate students of Ghana and Nigeria; find out the difference in the exercise Recovery- heart rate between undergraduate students of Ghana and Nigeria; and investigate the difference in the rate of Maximal Oxygen Consumption (VO_2 max) between undergraduate students of Ghana and Nigeria. The three questions explored were:

1. To what extent does Resting-heart rate differ between undergraduates of Ghana and Nigeria?
2. To what extent do undergraduates of Ghana differ from Nigeria undergraduates in their exercise recovery-heart rate?
3. To what extent does rate of VO_2 max differ between undergraduates of Ghana and Nigeria?

In order to answer the research questions the following null hypotheses were formulated to guide the study:

1. There is no significant difference in the resting heart rate of undergraduate students of Ghana and Nigeria
2. Exercise Recovery-heart rate of undergraduate students of Ghana do not differ significantly from undergraduate students of Nigeria.
3. Undergraduate students of Ghana and Nigeria do not differ significantly in their rate of VO_2 max.

LITERATURE REVIEW

The cardiovascular system responds to exercise through the cardiac output, blood flow, blood pressure, oxygen extraction and coronary circulation (Parampero, et al., 2013). Mesay and Verma (2008), opined that sports such as running, football, hockey etc., have intense period of work alternating with short to moderate periods of rest (or reduced activity), depending upon the specific demands of the sport. During short term high intensity maximal exercise, the creatine phosphate which is the most immediate reserve in the skeletal muscle is taxed to the maximum (Hultman & Harris, 2007). In addition, muscle and blood lactate concentrations are also significantly elevated after 10 seconds (Boobis et al 2003; Jacob et al., 2013).

Cardiac output is the total volume of blood pumped by the left ventricle of the heart per minute. It is the product of heart rate (number of beats per minute) and stroke volume (volume of blood pumped per beat). The arterial-mixed venous oxygen difference is the difference between the oxygen content of the arterial and mixed venous blood. A person's maximum oxygen uptake (VO2 max) is a function of cardiac output. Cardiac output thus plays an important role in meeting the oxygen demands for work. As the rate of work increases, the cardiac output increases in a nearly linear manner to meet the increasing oxygen demand (Petersen & Cooke, 2014)

According to Xiang and Hester (2018), the pattern of blood flow, changes dramatically when a person goes from resting state to exercising. At rest, the skin and skeletal muscles receive about 20 percent of the cardiac output. During exercise, more blood is sent to the active skeletal muscles and, as body temperature increases, more blood is sent to the skin. Also, Jacob et al. (2013) added that this process is accomplished both by the increase in cardiac output and by the redistribution of blood flow away from areas of low demand, such as the splanchnic organs. This process allows about 80 percent of the cardiac output to go to active skeletal muscles and skin at maximal rates of work (Rowell, 2006). With exercise of longer duration, particularly in a hot and humid environment, progressively more of the cardiac output will be redistributed to the skin to counter the increasing body temperature, thus limiting both the amount going to skeletal muscle and the exercise endurance (Rowell, 2006; Parampero et al., 2003).

After exercise, bodily processes do not immediately return to resting level. The variation in recovery from light, moderate and strenuous exercise is determined by specific metabolic and physiological processes resulting from each level of effort (Parampero et al., 2013, Gaesser and Brooks, 2004, Hultman et al., 2007). During the initial minutes of recovery, even though the muscle is no longer actively working, oxygen demands do not immediately decrease; instead oxygen consumption remains elevated, temporarily. This is due to restoration of metabolic processes to its pre-exercise levels. This consumption, which exceeds the usually required when at rest, has traditionally been referred to as the oxygen debt. A more common term today is excess post exercise oxygen consumption (Gaesser & Brooks, 2004).

The first phase of recovery is marked by rapidly declining VO2 and heart rate. It is during this period that tissue stores of the ATP and Phosphocreatine (PCr) depleted in the

muscles are restored within 30 seconds and 100% restored within 3 to 5 minutes (Hultman et al., 2007). The ability to maintain muscle performance during high intensity exercise depends on the recovery performance in many individual and team sports. According to Zafeiridis (2005) a higher rate of PCr re-synthesis, a greater ability to tolerate buffer and remove H+ and restore muscle pH and a greater oxidative enzyme activity may accelerate the recovery process.

Following maximum intensity work, exemplifies that glycolysis also present an important source of ATP re-synthesis in short duration exercise. The resulting drop in muscle pH may have a detrimental effect on subsequent performance. The return of exercising muscle towards resting pH and normal CP levels will consequently be an important component of recovery. The high correlation between recovery during intermittent exercise and creatine phosphate re-synthesis are consistent with this theory. A number of studies have concluded that recovery will be facilitated by an enhanced oxygen uptake capacity (Petersen & Cooke, 2014).

The ability to recover quickly is therefore important in many team sports like football, hockey and in combat sports like boxing, Judo, wrestling etc. Individual differences exist among sports person to metabolize lactate for example improvement of aerobic fitness plays a great role in recovery (Kylie et al. 2012). Some studies have supported an association between aerobic fitness and lactate removal (Tomlin & Wenger, 2001) following high intensity exercise, whereas some others have failed to confirm an association (Evans & Cureton, 2013; Gephine et al. 2020). However, according to Patel and Zwibel (2020), women and men who participate in exercise training have similar responses in cardiovascular, respiratory, and metabolic function (providing that size and activity level are normalized). Also, that Relative increases in VO2max are equivalent.

METHOD

An ex-post facto research design was adopted for the study. The population consisted of second year undergraduate students of both the Department of Sports and Exercise Medical Sciences, Ho, Ghana and second year students of the Department of Human Kinetics and Health Education, University of Calabar, Nigeria during 2021/2022 academic session totaling 85 students. A simple random sampling technique was employed to select, 50 participants that is 25 students each comprising 15 males and 10 females for the study. The 25 students were selected from Ghana and Nigeria respectively. The research instruments used in this study were standardized Instrument of 12 - minutes Run Test. Data collected were based on cardiorespiratory parameters in exercise which are Resting Heart rate (Rhr) which was taken before a dynamic exercise of 12-minute run, Exercise recovery Heart rate (ErHr) which was taken at intervals of 1, 2 and 3 minutes after exercise and Maximal oxygen consumption (VO_2 Max). Criterion reference standard was used to determine level of performance according to distance covered in the 12-minute run, while the distance covered was used to calculate (estimating) the rate of Maximal Oxygen Consumption (VO_2 max) using the formula according to Cooper (2005) $= \frac{d_{12} - 504.9}{44.73}$. Data was analysed using both Descriptive and inferential statistics of Independent t-test which was at .05 level of insignificance with 48 degree of freedom.

Criterion Reference Standard Table For a 12 - Minute Run
(Age: 20 - 29 years)

Table 1. Male

DISTANCE COVERED	PERFORMANCE LEVEL
>2800M	EXCELLENT
2400 – 2800M	ABOVE AVERAGE
2200 – 2399M	AVERAGE
1600 – 2199M	BELOW AVERAGE
<1600M	POOR

Source: Cooper, 2005

Table 2. Female

DISTANCE COVERED	PERFORMANCE LEVEL
>2700M	EXCELLENT
2200 – 2700M	ABOVE AVERAGE
1800 – 2199M	AVERAGE
1500 – 1799M	BELOW AVERAGE
<1500M	POOR

Source: Cooper, 2005

RESULTS

Table 3. Means, standard deviations, and independent t-values of cardiorespiratory response to stress exercise of Ghana and Nigeria **Male students.**

Variable	Country	N 30	Mean	Std. Dev	Cal. t	Crit. t	Decn.
Rest. H.R	Ghana	15	84.40	10.006	.626	2.048	*N/Sig.
	Nigeria	15	92.60	16.278			
Ex. Rec. H.R **1minute**	Ghana	15	110.40	23.655	.840		*N/Sig.
	Nigeria	15	124.80	34.570			
2 minutes	Ghana	15	107.53	24.386	.826		*N/Sig.
	Nigeria	15	121.40	38.064			
3 minutes	Ghana	15	103.33	26.084	.622		*N/Sig.
	Nigeria	15	116.15	34.213			
Dist. Covrd.	Ghana	15	2,156.93	279.148	3.851		**Sig.
	Nigeria	15	2,680.50	320.074			
VO_2 Max	Ghana	15	36.93	6.239	.859		*N/Sig.
	Nigeria	15	48.62	7.137			

***Not Significant; **Significant at .05 level: Critical t - value =2.048: df = 48
Rest H.R - Heart Rate Ex. Rec. H.R – Exercise Recovery Heart Rate
Dist. Covrd. - Distance Covered VO_2 Max - Maximal Oxygen Consumption

From Table 3, it can be deduced that the Resting heart rate or Heart rate before exercise for Male students of Ghana and Nigeria has a mean and standard deviation of 84.40±10.006; 92.60±16.278 respectively. This indicated that Ghanaian male students have a lower resting heart rate than their Nigerians counterparts. Meanwhile, there is no significant difference between the two categories of students when subjected to t-test statistics. The stress exercise recovery Heart Rate of male students in Ghana and Nigeria taken trice at intervals of one minute, 2 minutes and 3 minutes as shown in Table 3. with the mean and standard deviation values of 1minute (110.40±23.655; 124.80±34.570), 2minutes (107.53±24.386; 121.40±38.064) and 3minutes (103.33±26.084; 116.15±34.213) did not yield any significant difference.

The Nigerian male students covered more distance than the Ghanaian male students during the 12-minute run as reflected in the mean and standard deviation (2,156.93±279.148; 2,680.50± 320.074). However, when this is juxtaposed with the Criterion Reference standard result Table for a 12-minute run in Table 1, the Male Ghanaian students performed **"**Below Average**"** While Nigeria students performed **"**Above Average**"** by covering a longer distance than the Ghanaian students. This result may be because Nigerian students had a curriculum that exposed them to more contact hours of fieldwork which is an added advantage to developing endurance.
The Vo_2 Max values were not statistically significant between the male students of Ghana and Nigeria but the mean and standard deviation 36.93±6.239; 48.626±7.137, and 48. 626±7.137) showed that the Nigerian students have more VO_2 Max than Ghanaian students.

Table 4. Means, standard deviations, and independent t-values of cardiorespiratory response to exercise of Ghana and Nigeria **Female students.**

Variable	Country	N 20	Mean	Std. Dev	Cal. T	Crit. t	Decn.
Rest. H.R	Ghana	10	94.70	10.404	-2.462	2.101	*N/Sig.
	Nigeria	10	87.60	16.359			
Ex. Rec. H.R **1minute**	Ghana	10	131.40	14.049	-2.517		*N/Sig.
	Nigeria	10	117.60	30.502			
2minutes	Ghana	10	118.00	16.248	-1.189		*N/Sig.
	Nigeria	10	113.20	32.731			
3minutes	Ghana	10	107.20	10.675	-442		*N/Sig.
	Nigeria	10	105.40	30.910			
Dist. Covrd.	Ghana	10	1,162.40	257.852	4.470		**Sig
	Nigeria	10	1,947.50	310.125			
VO_2 Max	Ghana	10	30.70	10.4346	1.873		*N/Sig.
	Nigeria	10	32.253	6.9347			

***Not Significant, **Significant at .05 level; Critical t - value =2.101; df = 48
Rest H.R - Heart Rate **Ex**. Rec. H.R – Exercise Recovery Heart Rate
Dist. Covrd. - Distance Covered VO_2 Max - Maximal Oxygen Consumption

Table 4 indicated no significant difference between the Resting heart rate of female students of both Countries. Though the mean and standard deviation values (94.70±10,404; 87.60±16.359) showed that Nigerian female students has lower resting heart rate than Ghanaian students. Subsequently, Exercise recovery Heart Rate of female students of both countries taken trice at different intervals of 1minute (131.40±14.049; 117.60±30.502), 2minutes (118.00±16.248; 113.20±32.731) and 3minutes (107.20±10.675; 105.40±30.910) did not differ significantly when statistically subjected to t-test.

The female students registered significant difference in the distance covered as the Nigerian females covered a longer distance than the Ghanaian female students. Thus; it is evident in the values of mean and standard deviation (1,162.40±257.852; 1,947.50±310.125). Therefore, following the Criterion Reference standard result Table as contained in Table 2, The Ghanaian Female students performed **"Below Average"** while female students from Nigeria performed on **"Average"**. This may be as a result that

Nigerian students had a curriculum that exposed them to more contact hours of fieldwork which is an added advantage to developing endurance.

There was no significant difference in VO_2 Max between the females from both counties but the mean and standard deviation 48. 626±7.1373 showed that the Nigeria female students have more VO_2 Max than Ghanaian male and female students. Above all, in spite of the differences in the mean scores, the results indicated no significance differences in the variables compared. This therefore has answered all the research questions and the entire Null hypotheses were upheld: meaning that there is no significance difference in the Resting heart rate, Exercise recovery heart rate and rate of VO_2max between the male and female undergraduate students of the Department of Sports and exercise Medical Sciences, University of Health and Allied Sciences, Ghana and Male & female undergraduate students of the Department of Human Kinetics and Health Education, University of Calabar, Nigeria. These findings are therefore in conformity with Patel and Zwibel, (2020) when he stated that for the most part, women and men who participate in exercise training have similar responses in cardiovascular, respiratory, and metabolic function (providing that size and activity level are normalized). More so, the findings are in conformity with Antwi et al. (2024) who indicated that physical activity and exercises among the youth are adept at ensuring healthy physiological body and quality academic work. He further added that relative increases in VO_2max are equivalent.

CONCLUSION

The cardiorespiratory response to exercise is directly proportional to the skeletal muscle oxygen demands for any given rate of work, and oxygen uptake (VO2) increases with increasing rates of work. Dynamic exercise produces the most striking burden on the cardiorespiratory systems of any of the various stresses encountered in normal life. On the other hand some of the factors that bring about variation in heart rate include age, sex and fitness level. It is therefore recommended that: 1) The students should engage more on physical activities and exercise so that they climb the next rung of the ladder e.g., from "above" average to "excellent for the boys and from "average" to "above average" for the girls as far aerobic fitness is concerned; 2) The students should make aerobic exercise as part of life style because aerobic fitness plays a great role in exercise recovery.

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CONFLICT OF INTEREST

Authors of the manuscript declare there is no conflict of interest.

REFERENCES

Akameze, J. N, and Ajibola, C. A. (2017). Cardiovascular response to exercise among undergraduates of Human Kinetics and Health Education, University of Calabar. *Nigeria School Health Journal*, Vol. 29, No. 2, (Pg. 133 – 140).

Antwi, J., Appiah Kusi, F., Shum, W.H., & Mohammed, S. (2024). Genetics and Epigenetics from Physical Activity: Ghana Active School's Programme and Ambidextrous

Organisational Practices. Asian Journal of Education and Social Studies, 50 (2), 156-164. https://doi.org/10.9734/AJESS/2024/v50i21267

Bogdanis, G.C., Nevill, M.E., Bobbis, L.H. (1996). Recovery of power output and muscle metabolites following 30-s of maximal sprint cycling in man. *Journal of Physiology,* 482: 467-480.

Boobis, LH; William, C. and Wooten, S.A. (2003). Human muscle metabolism during brief maximal exercise*. Journal of. Physiology.,* 338: 21-22.

Cooper Institute for Aerobics Research (2005). The fitness Specialist Manual. Dallas: Author.

Evans, B.W. & Cureston, K.J. (2013). Effect of physical conditioning on blood lactate disappearance after supramaximal exercise. *British Journal of Sports Medicine,* 17: 40-45.

Gaesser, G.A and Brooks, G.A (2004). Metabolic Bases of exercises post exercise oxygen consumption. A review. *Medicine & Science in sports & Exercise Medicine*. 36, 29-43 https://www.scrip.org

Gephine, S; Bergoron, S; Tremblay, L.P.F; Mucci, P; Saey, D & Maltais. F (2020). Cardiorespiratory response during the 1-min sit-to-stand test in chronic obstructive pulmonary disease. *Medicine & Science in sports & Exercise Medicine.* 52 (7) 1441-1448

Hultman, E. and Harris, R.C. (2007). The time course of Phosphorylcreatin resynthesis during recovery of the quadriceps muscle in man. *Pflugers Arch.,* 367: 137-142.

Jacobs, I., Tesch, P.A., Bar-or, O., Karlsson, J. and Dotal, R. (2013). Lactate in human skeletal muscle after 10 seconds and 30 seconds of supramaximal exercise. *Journal of Applied Physiology*, 55: 365-367.

Kylie, H; Thomas E.O; Lynda, W; Debbie, C; Roger G; & Dinna, B (2012). Comparing Peak and Submaximal Cardiorespiratory responses during field walking tests with incremental cycle ergometry in COPD. 17 (2) https://doi//.org/10.1111

Matthews, D.K and Fox, E.L (2009). *The Physiological basis of physical education and athletes:* Canada. W.B Saunders

Mesay, D & Verma Sk. (2008). Comparison of Cardiovascular Responses to Exercise and Recvery pattern in Players. *Journal of Exercise Science and Physitherapy* 4 (1) 55-56.

Nobrega, A.C., O'Leary, D.O., Silva, B.M., Marongiu, E., Piepoli, M.F., and Crisafulli,A (2014). Neural regulation of cardiovascular response to exercise: Role of central command and peripheral afferents. https://pubmed.ncbi.nlm.nih.gov

Parampero, P.E., Mahler, P., Giezendarnner, D. and Cerretelli, P. (2013). The effect of priming exercise on VO2 kinetics and O2 deficit at the onset of stepping and cycling. *Journal of Applied Physiology*. 66: 2023-2031.

Patel, P. N & Zwibel, H (2020) Exercise Physiology. https://www.ncbi.nlm.nih.gov

Pedersen, B.K. & Cooke, P.H (2014) Cell response to physical activity: possible mechanisms of action. *Medicine and Science in Sports and Exercise.* 26:140–146.

phosphorylcreatin resynthesis during recovery of the quadriceps muscle in man. *Pflugers Arch.,* 367: 137-142.

Rowell, L. B. (2006) *Human Circulation*: Oxford University Press.

Tomli, D.L. & Wenger, H.A. (2001). The relationship between aerobic fitness & recovery from high intensity intermittent exercise. *Journal of Sports Medicine,* 31(1): 1-11.

Turley, K.R (2012). Cardiorespiratory responses to exercise in children. *Sports Med*. https://pubmed.ncbi.nim.nih.gov

Xiang, L and Hester, R (2018). Cardiovascular response to Exercise. Colloquium Series on Integrated Systems Physiology: From Molecule to Function, 3 (7) 1-124 https://doi.org/10.4199/C00040ED1V01Y201109ISP027

Zafeiridis, A. (2005). Recovery during high-intensity intermittent anaerobic exercise in boys, teens and men. *Jornal of Medicine and Science in Sport Exercise,* 37(3): 505-512.