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Cardiorespiratory Responses of Professional Male Volleyball and Basketball Players to Harvard Step Test

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Abstract*: Maximal rate of oxygen uptake is one of the most commonly measured parameters in basic and physiological sciences and it is frequently used to indicate the cardio-respiratory fitness of an individual. The purpose of this study was to compare the maximal oxygen uptake (VO_{2max}) and the cardio-respiratory responses of professional volleyball and basketball players to Harvard step test.Twenty-five volleyball players of mean age, height and weight of 26.16yrs, 1.80m, and 80.20kg and twenty-five basketball players of mean age, height and weight as 25.32yrs, 1.88m, 86.48kg were selected through purposive sampling and they performed the exercise protocol for five minutes after which there blood pressure and heart rate (HR) responses were measured. Mean arterial pressure (MAP) and rate pressure product (RPP) was also estimated from the blood pressure responses. The VO_2max (maximal oxygen uptake) was estimated using the equation; Fitness index (Short form) = (100 x test duration in seconds) divided by (5.5 x pulse count between 1 and 1.5), RPP was computed using the equation; HR x systolic blood pressure (SYS) and the MAP was calculated using; MAP = P_{diast}+ 1/3(P_{syst}- P_{diast}). Comparative analysis was done using descriptive statistics of mean and standard deviation, inferential statistics of independent t-test and Pearson moment product correlation with alpha level of significance set at 0.05.Statistically significant differences were recorded between VO_2 max of volleyball players; 39.07ml/kg/min, and basketball players 25.46ml/kg/min, while no statistically significant differences were recorded in their HR; 103.5bpm and 105.3bpm, SYS; 145.4mmHg and 136.7mmHg, diastolic blood pressure(DBP); 76.3mmHg and 74.7mmHg, RPP; 15200mmHg.bpm and 14548mmHg.bpm, MAP; 91.5mmHg and 89mmHg of professional basketball and volleyball players respectively. Positive significant correlations were recorded between the VO_2max and RPP (p=0.001), MAP and RPP (p=0.02), MAP and SYS (p=0.00) of basketball players. A Positive significant correlation was recorded between the MAP and RPP (p=0.001), MAP and SYS (p=0.00) of volleyball players. A negative significant correlation was recorded between the VO_2max and RPP (p= -0.8) of volleyball players. These data shows that volleyball players had higher VO_2max than basketball players which implies that they have better cardio-respiratory endurance level. Frequent training among these athletes will help to reduce the incidence of detraining as this will invariably lead to decrease in aerobic capacity and cardio-respiratory fitness.*

I. Background of study

Competitive volleyball is one of the most malleable sports around because it is played in many variations and on many different surfaces. It is a contact game made up of six payers in which the player contacts the ball more than three times on a side [1]. Athletico Physical Therapy reports volleyball will boost your muscle toning and overall strength, particularly your arms, legs and core [1].

Competitive basketball is a non-contact game of intermittent high intensity physical activity that requires a well-developed aerobic and anaerobic fitness [2]. In as much as basketball performance is thought to be mainly dependent on the players anaerobic ability, high aerobic fitness is also important for improved performance [3].

Cardiorespiratory fitness is the ability of the body's circulatory and respiratory systems to supply fuel and oxygen during sustained physical activity[4].Cardiovascular fitness reflects the ability of the lungs, blood, heart, muscles, and other organs and organ systems to transport and utilize O_2 via the aerobic metabolic pathways thus determining a person's level of cardiorespiratoryfitness has both general and clinical applications [5].The maximum volume of oxygen your body can consume and use is your maximal oxygen consumption(VO_2max)[4].The criterion measure of cardio-respiratory fitness is maximal oxygen uptake typically expressed in liters of O_2 consumed per minute ($L\cdot min^{-1}$) or millilitres of O_2 consumed per kilogram of body mass per minute ($mL\cdot kg^{-1}\cdot min^{-1}$)[6]

Maximal rate of oxygen uptake is one of the most commonly measured parameters in basic and physiological sciences and it is frequently used to indicate cardiorespiratory fitness of an individual [7]. Maximum oxygen uptake (VO_2 Max) is defined as the highest rate at which oxygen can be taken up and utilized by the body during severe exercises [7].

Another parameter that measures cardiorespiratory fitness is the rate pressure product.

Rate pressure product is a term used in cardiology, as well as exercise physiology, to measure the Workload or oxygen demand of the heart, and reflects hemodynamic stress [8]. Rate pressure product is a major determinant of myocardial oxygen consumption as well as anImportant indicator of ventricular function [9].It is measured at rest and during various stages of exercise. At the conclusion of each stage of an exercise stress test, the heart rate and blood pressure is documented, which is used to compute the rate pressure product. It is a product of systolic blood pressure multiplied by the heart rate [10]. Studies have shown that lower rate pressure product observed at maximal workload was entirely due to lower systolic blood pressure [11].

Mean arterial pressure is another parameter that measures cardiorespiratory fitness. Mean arterial pressure is defined as the average pressure in the arteries over a certain time interval [12]. Mean arterial pressure can be approximated by adding the diastolic pressure to one-third the difference between the systolic and diastolic pressures [13]. The mean arterial pressure is dependent upon the peripheral resistance and the cardiac output of the heart [13]. Cardiac output is the inflow into the arteries from the heart, and peripheral runoff is defined as the outflow into the resistance vessels from the arteries [13]. If the cardiac output is greater than the peripheral runoff, mean arterial pressure increases. If the reverse is true, the mean arterial pressure decreases. If the two parameters are equal, then mean arterial pressure remains constant. It is calculated using the formula; $MAP = P_{diast} + 1/3(P_{syst} - P_{diast})$ [13].

Step tests are one of the most widely used tests for estimating VO_2max [14]. In step tests, oxygen consumption is usually estimated from an equation rather than directly measured [15]. This study will use the Harvard step test to determine the cardio-respiratory fitness of the professional volleyball and basketball players. The Harvard step test is a method used to access cardiorespiratory fitness and was developed by Brouha et al, in the Harvard fatigue laboratory[16]. Harvard step test requires the subject to step up and down a step or platform of 20 inches at the rate of 30 steps per minute (every two seconds) for 5minutes or until exhaustion at a rate set on the metronome. Exhaustion is defined as when the athlete cannot maintain the stepping rate for 15seconds [17]. The subject immediately sits down on completion of the test and the total number of heart beats are counted between 1 to 1.5minutes after finishing. The work done by Dill et al revealed that athletes lose their aerobic capacity as a result of neglect in keeping to their training [18]. A sub-optimal level of cardio-respiratory fitness is a risk factor for coronary heart disease and other chronic diseases among adults, such as colorectal cancer, type II diabetes, depression, and is associated with all-cause mortality [19].

It has been observed by the researcher that most professional basketball and volleyball teams perform poorly in competitions. Studies have shown that a good level of aerobic capacity is important for good performance for athletes [19]. Poor level of cardio-respiratory fitness leads to poor performance and frequent fatigue among athletes during competitions [20]. Based on the importance of all these cardiorespiratory and vascular parameters in athletic performance, the problem of poor performance and selection among athletes may be attended to thereby helping in their performance level. Data from numerous epidemiological studies indicate that low cardio-respiratory fitness is a strong independent risk factor for all-cause and cardiovascular disease mortality in asymptomatic individuals, persons with comorbid conditions (hypertension, obesity, and type 2 diabetes mellitus), and those with established coronary artery disease [21].

There are few established data on the physiological profile of volleyball and basketball players from this part of the country, although there are numerous published reports for North America, European and Australian volleyball and basketball players.

II. Method

The research design used was a pre-test post-test experimental design**.** This study comprised of professional volleyball players and basketball players from a south eastern state in Nigeria. The sampling technique used for this study was the purposive sampling technique. The sample size for this study was 50 participants; 25volleyball players and 25basketball players from Anambra state volleyball and basketball teams respectively.

Instrumentation;

1. A Step or platform of 20inches/50.8cm high constructed in Nigeria
2. Bathroom scale (Model hamason, China)
3. Stop watch (Kadio model KD-1069, China)
4. Height meter (made in Nigeria)
5. An electronic blood pressure monitor (made in china)
6. Mobile Metronome (Android mobile version 1.2.4)

Procedure for data collection:

Ethical approval was sought from the ethical review committee of the Nnamdi Azikiwe University Teaching Hospital Nnewi. Also informed consent was sought from the participants before the test is carried out.

All the participants were familiarized with the Harvard step test prior to the test. Upon arrival of the venue of research, each participant rested for at least 5minutes before engaging in the exercise protocol after which resting blood pressure and heart rate was taken in a sitting position.

Exercise Protocol:

Harvard step test requires the subject to step up and down a step or platform of 20inches at the rate of 30 steps per minute (every two seconds) for 5minutes or until exhaustion at a rate set on the metronome. Exhaustion is defined as when the athlete cannot maintain the stepping rate for 15second [17]. The subject immediately sits down on completion of the test and the total numbers of heart beats are counted between 1 to 1.5minutes after finishing. This is the only measure required when using the short form of this test [17].At the end the blood pressure will be measured immediately and the recovery heart rate recorded after 15 seconds.

Scoring of the test; The Harvard test was scored using the fitness index score. The fitness index score is determined by the following equation; Fitness index (Short form) = (100 x test duration in seconds) divided by (5.5 x pulse count between 1 and 1.5)[22].

III. Method of Data Analysis

The data obtained from this study was analyzed using descriptive statistics of mean and standard deviation, inferential statistic of independent t-test and Pearson moment product correlation with the level of significance set at 0.05.

Result

Participants Profile

Fifty participants were involved in this study; twenty-five male basketball and twenty-five male volleyball players; Table 1 shows the mean and standard deviations of the anthropometric variables of age, height and weight of professional male volleyball and basketball players respectively.

Estimated Maximum Oxygen Uptake (VO_2max) and Heart Rate Responses of Professional Male Volleyball and Basketball Players to Harvard Step Test.

As shown in Table 2; the VO_2max of volleyball players (39.07±11.4ml/kg/min) was significantly higher ($P<0.001$) than the basketball players (25.46± 15.7ml/kg/min) with ($P<0.001$). Table 2 also shows an average mean heart rate of basketball players 91.7±17.54bpm and the volleyball players 88.36 ±13.46bpm before the exercise. In response to the sub-maximal step test the basketball players showed an insignificantly higher mean heart rate of 105.28±16.19 than the volleyball players 103.48±27.54.

Systolic and Diastolic blood pressure responses of professional male volleyball and basketball players to Harvard step test.

As shown in table 3; basketball players had a higher baseline systolic blood pressure of 121.92±24.2mmHg and diastolic blood pressure of 78.32±13.24mmHg than the volleyball players who had systolic blood pressures of 118.32±27.54mmHg and diastolic blood pressures of 76.32±13.77 mmHg before the step test. In response to the sub-maximal step test the basketball players had insignificantly higher systolic blood pressures of 145.36±21.57 mmHg and diastolic blood pressures of 76.28±13.72 mmHg than the volleyball players who had systolic blood pressures of 136.68±29 mmHg and diastolic blood pressures of 74.72±12 mmHg.

Mean arterial pressure and rate pressure products of professional male volleyball and basketball players to Harvard step test.

Table 4 shows that basketball players had a higher baseline mean arterial pressure of 91.45±13.9mmHg than the volleyball players who had mean arterial pressures of 89±15.8 mmHg before the test. In response to the sub-maximal step test the basketball players had insignificantly higher mean arterial pressures of 97±14 mmHg than the volleyball players who had mean arterial pressures of 92.9±13.6 mmHg. Table 4 also shows the rate pressure product of basketball players who had higher baseline rate pressure products of 11162.92±3086.22mmHg.bpm than the volleyball players who had rate pressure products of 10472.2±3141.8 mmHg.bpm before the step test. In response to the sub-maximal step test the basketball players had significantly higher rate pressure products of 15200±5026.8 mmHg.bpm than the volleyball players who had rate pressure products of 14548±4422.8 mmHg.bpm.

Pearson correlation of VO2max, mean arterial pressure, rate pressure product, and systolic blood pressure of professional basketball players.

Table 5 shows a positive significant correlation between the VO_2max and rate pressure product (p=0.01), mean arterial pressure and rate pressure product (p=0.02) and the mean arterial pressure and systolic blood pressure (p=0.00) of the professional volleyball players. No significant correlation was shown between the VO_2max and mean arterial pressure and also the VO_2max and systolic blood pressures of the basketball players.

Pearson correlation of VO_2max, mean arterial pressure, rate pressure product, and systolic blood pressure of professional volleyball players.

Table 6 shows a negative significant correlation between the VO_2max and rate pressure product (p= -0.8), mean arterial pressure and rate pressure product (p=0.001) and the mean arterial pressure and systolic blood pressure (p=0.00) of the professional volleyball players. No significant correlation was shown between the VO_2max and mean arterial pressure and also the VO_2max and systolic blood pressures of the volleyball players.

Table 1; Anthropometric Measures of professional male basketball and volleyball players

		Age (Yrs)	Height (m)	Weight (kg)
VBP				
	Mean	**25.32**	**1.88**	**86.48**
	S D	**6.11**	**0.097**	**17.92**
BBP				
	Mean	**26.16**	**1.80**	**80.20**
	S D	**5.79**	**0.06**	**8.33**

KEY; VBP: Volleyball players BBP: Basketball players S D: Standard deviation

Table 2; Estimated maximum oxygen uptake (VO_2max) and heart rate responses of professional volleyball and basketball players.

		N	Mean	S D	t-value	P-value
VO_2max	BBP	25	25.5	15.740	-3.502	0.001
(kg/ml/min)	VBP	25	39.072	11.401		
Post-HR	BBP	25	103.480	27.541	-2.82	0.779
(Beats/min)	VBP	25	105.280	16.193		
Pre-HR	BBP	25	91.720	17.544	0.760	0.451
	VBP	25	88.360	13.456		

KEY: HR: Heart Rate

Table 3; Blood pressure responses of professional basketball and volleyball players to Harvard step test

		N	Mean	SD	t-value	P-value
Pre-DBP	BBP	25	78.320	13.25	0.523	0.603
(MmHg)	VBP	25	76.320	13.77		
Post-DBP	BBP	25	76.280	13.722	0.427	0.671
	VBP	25	74.720	12.029		
Pre-SBP	BBP	25	121.920	24.211	0.491	0.626
(MmHg)	VBP	25	118.320	27.542		
Post-SBP	BBP	25	145.360	21.571	1.20	0.236
	VBP	25	136.680	29.00		

KEY;DBP; Diastolic Blood PressureSBP; Systolic Blood Pressure

Table 4; Mean arterial pressure and rate pressure product of professional male volleyball and basketball players to Harvard step test.

		N	Mean	S D	t-value	P-value
VO_2max	BBP	25	25.5	15.740	-3.502	0.001
(kg/ml/min)	VBP	25	39.072	11.401		
Post-HR	BBP	25	103.480	27.541	-2.82	0.779
(Beats/min)	VBP	25	105.280	16.193		
Pre-HR	BBP	25	91.720	17.544	0.760	0.451
	VBP	25	88.360	13.456		

KEY;MAP: Mean arterial pressure RPP: Rate pressure product

Table 5; Pearson Correlation of MAP, SYS, VO2max and RPP of professional basketball players

	N	MAP	VO_2max	SYS	RPP
MAP Pearson correlation	25		-1.95	0.82	0.45
P value			0.35	0.00	0.24
VO_2max Pearson correlation	25	-1.95		-0.32	-0.60
P value		0.35		0.120	0.001
SYS Pearson correlation	25	0.815	-0.319		0.68
P value		0.00	0.120		0.00
RPP Pearson correlation	25	0.45	-0.603		0.68
P value		0.24	0.001		0.00

KEY;SYS; Systolic blood pressureMAP; Mean arterial pressureRPP; Rate pressure productVO_2max; maximal oxygen uptake

Table 6; Pearson Correlation of MAP, SYS, VO2max and RPP of professional volleyball players

	N	VO_2max	MAP	RPP	SYS
VO_2max	25		0.2	-0.08	0.90
p value			0.94	0.704	0.67
MAP	25	0.16		0.64	0.78
p value		0.94		0.00	0.00
RPP	25	-0.08	0.64		0.88
p value		0.70	0.00		0.00
SYS	25	0.89	0.78	0.66	
p value		0.67	0.00	0.00	

KEY; SYS; Systolic blood pressureMAP; Mean arterial pressureRPP; Rate pressure productVO_2max; maximal oxygen up

IV. DISCUSSION

The aim of this study was to estimate the maximum oxygen uptake, and compare the heart rate response, blood pressure, mean arterial pressure, and rate pressure product of volleyball and basketball players to Harvard step test. Fifty participants were involved which comprised of twenty-five volleyball and twenty-five basketball players. The study showed that volleyball players had significantly higher VO_2 max (39.07±11.4ml/kg/min), than the basketball players (25.46± 15.7ml/kg/min), indicating that volleyball players had more aerobic capacity than basketball players. High VO_2 max is the primary indicator of aerobic fitness, cardiovascular health, and endurance performance [15, 23, 24]. A study carried out by Enumah revealed a significantly higher VO_2max among football players than the basketball players due to the combined effect of covered distance owing to the large football pitch and a longer duration of play when compared to basketball pitch and duration of play[25]. The intensity and duration of volleyball game maybe the reason why volleyball players had significantly higher VO_2max than the basketball players. This is also in line with the work of Hill and Lupton which showed that as exercise intensity increases, maximum oxygen consumption increases proportionally [26]. Based on the Harvard step rating the VO_{2max} of the volleyball and basketball players falls within a poor range (<55) indicating that they have poor cardio-respiratory fitness The researcher also observed that during the sub-maximal step test, majority of the volleyball players were able to maintain a stepping rate for 5minutes unlike most of the basketball players who couldn't maintain an endurance of 5minutes during the step test thus accounting for the higher VO_2max seen among the volleyball players.

The study showed an insignificant baseline mean heart rate of basketball players 91.7±17.54bpm than the volleyball players 88.36 ±13.46bpm before the exercise. In response to the sub-maximal step test the basketball players showed an insignificant higher mean rate of 105.28±16.19 than the volleyball players 103.48±27.54. Halliwill et al reported that after an acute bout of moderate exercise, baro- reflex control of heart rate and blood vessels is distinctly regulated [27]. In other words, sympathetic drive to the heart increases, while sympathetic drive to blood vessels decreases. Thus, it is possible that different exercise intensities may distinctly affect the baro-reflex control of heart rate, but not the baro-reflex control of blood vessels. However, the vasodilatatory response and the decrease in blood volume may play a role in the post-exercise blood pressure fall. It is well understood that muscle metabolites and heat accumulation are directly related to exercise intensity, and sweating rate is greater during more intense exercise. In addition, the increased local muscle metabolites and heat production are also potential stimuli for the increased heart rate responses after moderate and high intensity exercise. According to Skime and Boon, heart rate is responsible for an increase in cardiac output [28]. This happens through the fundamental sympathetic nervous system with the onset of exercise. Heart rate increases because of the vasodilatation of the blood vessels, transporting more oxygenated blood to the working muscles. This transported oxygen to active tissue is usually interpreted because of the increased vasodilatation. The endothelium of the blood vessels becomes stimulated through shear stress, while nitric oxide and adenosine and acetylcholine act as potent vasodilators. Ultimately, blood flow of contracting and working skeletal muscle is a balance between metabolic vasodilatation and sympathetic vasoconstriction

Furthermore Evans et al reported that peripheral adaptation such as duration of the exercise, total area covered during exercise that are associated with training may also contribute to exercise bradycardia[29]. So it can be said that the lower heart rate of volleyball players compared to the basketball players as observed in this study is as a result of the combined effect of both the altered autonomic function, decreased sensitivity of the baro-receptor, and peripheral adaptation.

The study revealed that basketball players had an insignificantly higher baseline systolic blood pressure of 121.92±24.2mmHg and diastolic blood pressure of 78.32±13.24 than the volleyball players who had systolic blood pressures of 118.32±27.54mmHg and diastolic blood pressures of 76.32±13.77 before the step test. In response to the sub-maximal step test the basketball players had insignificantly higher systolic blood pressures of 145.36±21.57 and diastolic blood pressures of 76.28±13.72 than the volleyball players who had systolic blood pressures of 136.68±29 and diastolic blood pressures of 74.72±12. This increase in systolic blood pressure and the decrease in the diastolic blood pressure of both groups observed at the end of the test is a normal physiologic response to exercise. Finnoff et al reported similar findings that dynamic exercise causes an increase in arterial blood pressure due to combination of an increase in cardiac output and in total systemic vascular resistance [30]. Systolic blood pressure will rise in a pattern very similar to that of cardiac output. The increase in systolic blood pressure is brought about by the increase in cardiac output. Systolic blood pressure would even be higher if not for the fact that resistance decreases, thereby partially offsetting the increase in cardiac output. Diastolic blood pressure remains relatively constant because of peripheral vasodilatation which facilitates blood flow to the working muscles. An immediate reduction in blood pressure following exercise has been termed 'post-exercise hypotension' and is agreed to be caused by reductions in vascular resistance [31]. The mechanisms associated with the chronic adaptations to blood pressure are more complex. A recent meta-analysis supports this chronic role being partially explained by a decreased systemic vascular resistance in which the autonomic nervous system and renin-angiotensin system (a hormone system that helps normalize long-term blood pressure and blood volume in the body) are most likely the underlying regulatory mechanisms [32]. Another factor contributing to this decrease in vascular resistance is the increase of nitric oxide production causing a vasodilatation in response to regular aerobic exercise [33].

The study also revealed that basketball players had an insignificantly higher baseline rate pressure product of 11162.92±3086.22 than the volleyball players who had rate pressure products of 10472.2±3141.8 before the step test. In response to the sub-maximal step test the basketball players had insignificantly higher rate pressure products of 15200±5026.8 than the volleyball players who had rate pressure products of 14548±4422.8. In the study by Ferris et al showed that rate pressure product at exercise peak were lower in patients without significant risk of cardiovascular disease as compared to those with significant risk of cardiovascular disease [34]. Such findings agree with our results in the sense that most individuals in our population fell within the range of low hemodynamic response (1000-14999) for volleyball players and low intermediate hemodynamic response (15000-19999) for basketballers indicating no significant coronary injury, thus presupposing better ventricular function during exercise. Higher rate pressure product seen among the basketball players indicates that they have better myocardial energy consumption than the volleyball players.

A study conducted by Forjaz et al, also demonstrated that an acute bout of low intensity exercise, besides producing lower increases in rate pressure product during exercise, also decreases post-exercise rate-pressure product below resting levels [35]. Hence it reduces myocardial oxygen consumption and, consequently, the cardiovascular risks after exercise. In contrast, moderate and high intensity exercise bouts produce greater increases in rate pressure product during exercise and fail to reduce rate pressure product below baseline during the recovery period. These findings, if reproducible in cardiac patients, may have clinical implications, especially in relation to exercise prescription in cardiac rehabilitation programs.

The study equally revealed that basketball players had an insignificantly higher baseline mean arterial pressure of 91.45±13.9 than the volleyball players who had mean arterial pressures of 89±15.8 before the test. In response to the sub-maximal step test the basketball players had insignificantly higher mean arterial pressures of 97±14 than the volleyball players who had mean arterial pressures of 92.9±13.6. Mean arterial pressure is normally between 70 and 110 mmHg [36]. The mean arterial pressure of basketball and volleyball players falls within the normal range of mean arterial pressure. This indicates that both basketball and volleyball players have enough oxygen perfusion pressure and are not at risk of trauma, intracranial bleed, stroke and hypertensive emergencies. . The small rise in systolic blood pressure and the lack of a significant change in diastolic blood pressure cause the mean arterial pressure (MAP) to rise only slightly, following the pattern of systolic blood pressure

Mean arterial pressure that falls below an appreciable time have been shown as advantageous targets for sepsis, trauma, stroke, intracranial bleed, and hypertensive emergencies [37]. The study did not show any significant correlation between the VO_2max and mean arterial pressure of basketball and volleyball players in response to the Harvard step test .The study revealed a positive significant correlation between the VO_2max and rate pressure products of basketball players and negative significant correlation between the VO_2max and rate pressure product of professional volleyball players to Harvard step test. This is in line with the work of other authors which clearly stated that in sub-maximal step test recovery heart rate provided significant information about VO_2max[8]. They found that subjects with high recovery heart rate and a slow decrease pattern tended to have a lower VO_2max whereas a faster recovery (faster reduction, lower heart rate) related to relatively high VO_2max values. This significant relationship revealed shows that both basketball and volleyball players have good ventricular function during exercise.

The study revealed a positive significant correlation between the mean arterial pressures and rate pressure products, mean arterial pressures and systolic blood pressures of basketball and volleyball players to Harvard step test. This significant correlation revealed is because myocardial oxygen consumption increases during dynamic aerobic exercise because the heart must do more work to pump an increased cardiac output to the working muscles. The rate-pressure product will increase in relation to increases in heart rate and systolic blood pressure, reflecting the greater myocardial oxygen demand of the heart during exercise [19]. Systolic blood pressure is caused by the increased cardiac output, which outweighs the decrease in resistance [19]. Systolic blood pressure and heart rate are two variables that are routinely monitored during an exercise test to ensure the safety of the participant. If either of these variables fails to rise with an increasing workload, cardiovascular insufficiency and an inability to adequately profuse tissue may result. Diastolic blood pressure typically remains relatively constant or changes so little with no physiological significance, although it may decrease at high levels of exercise. Diastolic pressure remains relatively constant because of the balance of vasodilatation in the vasculature of the active muscle and vasoconstriction in other vascular beds. These significant correlations observed in this study are as a result of increase in systolic blood pressure and diastolic blood pressure which are normal physiologic response to exercise. Whelton et al reported that chronic aerobic exercise exerts a significant anti-hypertensive effect while Pescatello and Kulikowich reported that acute exercise results in post-exercise hypotension [38, 39].

V. Conclusion

Based on the findings of this study the researcher reached the following conclusions:Volleyball players had higher VO_2max than basketball players which implies that they have better cardio-respiratory endurance level.Frequent training among these athletes will help to reduce the incidence of detraining as this will invariably lead to decrease in aerobic capacity and cardio-respiratory fitness.

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