

## An Investigation into the Measurement Level of Maximum Volume of Oxygen (VO<sub>2</sub> Max) Consumption Using Cooper 12-Minutes Run-Test

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### Abstract

This study was carried out to investigate the measurement level of maximum volume of oxygen (VO<sub>2</sub> max) rate for a continued period of four weeks (one month) amongst randomly selected Bo Commercial Junior Secondary School (JSS I, II and III) pupils in the Bo Municipality, Sierra Leone. The significance of the study is to measure and compare the VO<sub>2</sub> max of both boys and girls at the three different strata i.e. JSS I, II & III using cooper-12-minutes-run test. A total of thirty (30) pupils (15 boys and 15 girls) were randomly selected at the three levels (JSS I, II & III), with age ranging from ten to seventeen (10-17) years. The Pearson Product Moment Correlation (PPMC) Coefficient, Dependent and Independent t-tests were used to compare the results of the study. The results were tested at ( $p \leq 0.05$ ) level of significance. Analysis of results from weeks one, two, three and four shows both significant and insignificant differences between the measured values of VO<sub>2</sub> max rate of boys and that of girls (JSS I, II & III) at the beginning and at the end of the exercise which is recorded as r values [(i.e. r values ranging from  $r = 0.0000$  to  $r = 0.7442$ ) when compared with the c value (i.e. c value = 0.8783)] as shown in tables I, II, III and IV; and as t values [(i.e. t values ranging from  $t = 10.249$  to  $t = 3.728$ ) when compared with the dependent and independent c values ( $c = 2.776$  and  $c\text{-value} = 2.306$ )] as shown in tables V, VI, VII, VIII, IX, X, XI and XII. Conclusively therefore, the major findings in this study shows that pupils (boys and girls) were experiencing quick fatigue at the beginning of the exercise which affected the low rate of their VO<sub>2</sub> max calculation greatly but they had to overcome the fatigue as the session continued into the subsequent weeks thereby improving their rate. In recommendation, the most effective approach to improving VO<sub>2</sub> max rate in pupils is by applying the endurance high intensity interval training (HIIT) during practical session in schools.

### Introduction

Physical activity is important for children's current and future health with

current recommendations calling for at least 60 minutes of moderate to vigorous physical activity at least 3 times a week

(Biddle et al., 1998; U.S. Department of Health and Human Services, 2000; National Association for Sports and Physical Education, 2004). School-based physical education (PE) is one of only five interventions strongly recommended as a means for increasing physical activity by the Task Force on Community Preventive Services (Centre for Disease Control and Prevention, 2001; Kahn, Ramsey, Brownson, Heath, Howze & Powell, 2002).

The recognition that physical fitness is a major marker of health status at any age (Ortega et al., 2007), has produced a wide range of studies on the influence of various factors on physical fitness levels, in particular the influence of body fat and physical activity (Lennox et al., 2008; Artero et al., 2010; D'Hondt et al., 2009; Dumith et al., 2010;). Increasing both aerobic and muscular fitness is essential for promoting health (American College of Sports Medicine, 2007) and should be a desirable goal in a training program (Taanila et al., 2011).

Children with high levels of motor competence are more active, more capable (Castelli et al., 2007) and spend less time on sedentary tasks (Wrotniak et al., 2006). On the other hand, improvement in the motor proficiency of children can also influence levels of habitual physical

activity beyond school age, creating expectations of future maintenance of active lifestyles (Sharkey, 2002; Andersen et al., 2004) and is thus indispensable to potential decisions influencing the promotion of health (Stodden et al., 2008). Health-related fitness includes, besides others, aerobic endurance, muscular strength, and flexibility (Hands et al., 2009). Schools also provide a resource for describing activity levels in children because they offer structured activity classes (physical education) and unstructured time (recess) (Caspersen, et al., 2000).

Cooper's 12 minute run test (Cooper, 1968) is a popular field test used for measuring aerobic fitness. This fitness test was initially used to estimate the VO<sub>2</sub> max. Cooper found a very high correlation between the maximum distance one can run (or walk) in 12 minutes and the VO<sub>2</sub> max value, which measure the efficiency with which someone can use oxygen while exercising. This test is still one of the basic fitness tests used by the military, as well as many coaches, trainers and an individual to determine cardiovascular fitness and track fitness over time. This simple test also allows individuals to compare their cardiovascular endurance with others of the same age and gender. VO<sub>2</sub>max (or

maximal oxygen consumption) is simply the maximum possible VO<sub>2</sub> that a given person can achieve. VO<sub>2</sub> and VO<sub>2</sub>max are important in the context of exercise, because they are a measure of one's body's ability to generate ATP, and ATP is the energy source that allows your muscles to continue working while you are exercising. Therefore, by definition, a VO<sub>2</sub> max measurement is ultimately a measure of your cardiorespiratory fitness level (Heyward, 2006).

This study only emphasized on the measurement of maximum volume of oxygen (VO<sub>2</sub> Max) rate through Cooper 12-minutes-run test amongst Bo Commercial Junior Secondary School (JSS) pupils ranging from JSS I, II and III in the Bo Municipality, Sierra Leone. This study also compared the significant difference of VO<sub>2</sub> Max between boys and girls with respect to their age range and class level.

## Material and Methods

### *Selection of participants:*

The study was performed on both 15 JSS boys and 15 JSS girls. The average age of both groups of pupils were ranged from 11 – 17 years. Both groups of pupils were

from the same micro socioeconomic background and were selected for the study on the basis of random sampling from JSS I, II and III sectors of Bo Commercial Secondary School, Bo, Sierra Leone respectively.

### **Instruments for measuring the parameter**

Instruments such as the data collection guide sheet, measuring tape, stop watch, pen and pencil, scientific calculator and whistle were used for measuring recording and calculating the required parameters. The school register was used to estimate the age range of the pupils i.e. JSS I, II & III.

### *Test Procedures:*

A well scaled 400 meter track was used to conduct the Cooper 12 minutes run test and the pupils were given a trial run on the first day of the exercise to familiarize themselves with the nature of the experiment for few minutes before the actual time of the test. After the familiarization exercise, the pupils were asked by the researcher to queue up for an experimental start. The pupils were then asked individually to run as many laps of the 400 meter track as possible for a maximum period of 12 minutes. At exactly

12 minutes, the whistle was sounded for participants to immediately stop running. Then total distance in meters covered after 12 minutes by each individual pupil was then recorded.

Below is the formula for Cooper's 12 minute run test (Copper, 1968) that was used to predict the VO<sub>2</sub> max of the pupils who participated in the exercise. Where d<sub>12</sub> is the total laps of the 400 meter track covered in 12 minutes.

$$VO_2 \text{ max} = \frac{d_{12} - 505}{45}$$

## Results:

**Table I: Pearson Products Moment Correlation Coefficient (PPMCC = r), shows the scores of ten (10) JSS I pupils [boys (x) and girls (y)] in week one VO<sub>2</sub> max exercise using the Cooper-12-minutes aerobic run test.**

Age	VO <sub>2</sub> max. for Boys (x)	VO <sub>2</sub> max. for Girls (y)	x <sup>2</sup>	y <sup>2</sup>	Xy
10-11	31.4	30.5	985.96	930.25	957.7
11-12	35.0	24.3	1225.0	590.49	850.5
12-13	35.0	28.8	1225.0	829.44	1008.0
13-14	42.1	32.3	1772.41	1043.29	1327.53
14-15	42.1	36.8	1772.41	1354.24	1549.28
* ∑	<b>189.6</b>	<b>152.7</b>	<b>6980.78</b>	<b>4747.71</b>	<b>5693.01</b>
	* (∑x) <sup>2</sup> = 35948.16	* (∑y) <sup>2</sup> = 23317.29	*r = 0.7341	*c = 0.8783	

**Table II: Pearson Products Moment Correlation Coefficient (PPMCC = r), shows the scores of ten (10) JSS II pupils [boys (x) and girls (y)] in week one VO<sub>2</sub> max exercise using the cooper-12-minutes aerobic run test.**

Age	VO <sub>2</sub> max. for Boys (x)	VO <sub>2</sub> max. for Girls (y)	x <sup>2</sup>	y <sup>2</sup>	Xy
11-12	36.8	22.5	1354.24	506.25	828.0
12-13	40.3	19.0	1624.09	361.0	765.7
13-14	36.8	27.0	1354.24	729.0	993.6
14-15	42.1	36.8	1772.41	1354.24	1549.28
15-16	42.1	36.8	1772.41	1354.24	1549.28
* ∑	<b>198.1</b>	<b>142.1</b>	<b>7877.44</b>	<b>4304.73</b>	<b>5685.86</b>
	* (∑x) <sup>2</sup> = 39243.61	* (∑y) <sup>2</sup> = 20192.41	*r = 0.6387	*c = 0.8783	

*Statistical Analysis:* The Pearson Product Moment Correlation (PPMC) Coefficient, Dependent t-test and Independent t-test were collectively used to analyze the data obtained through a rearranged data collection guide that was originally developed in 1982 (recently updated in 2005) by The Cooper Institute in Dallas, TX to measure kids' fitness and find out whether there were significant differences in VO<sub>2</sub> max rate between boys and girls of JSS I, II and III according to their age range. The results were tested at p ≤ 0.05 level of significance.

**Table III: Pearson Products Moment Correlation Coefficient (PPMCC = r), shows the scores of ten (10) JSS III pupils [boys (x) and girls (y)] in week one VO<sub>2</sub> max exercise using the Cooper-12-minutes aerobic run test.**

Age	VO <sub>2</sub> max. for Boys (x)	VO <sub>2</sub> max. for Girls (y)	x <sup>2</sup>	y <sup>2</sup>	Xy
12-13	44.8	25.2	2007.04	635.04	1128.96
13-14	52.7	35.9	2777.29	1288.81	1891.93
14-15	50.1	38.6	2510.01	1489.96	1933.86
15-16	50.1	47.4	2510.01	2246.76	2374.74
16-17	55.4	46.5	3069.16	2162.25	2576.1
*Σ	<b>253.1</b>	<b>193.6</b>	<b>12873.51</b>	<b>7822.82</b>	<b>9905.59</b>
*(Σx) <sup>2</sup> = 64059.61		*(Σy) <sup>2</sup> = 37480.96		*r = 0.7442 *c = 0.8783	

**Table IV: Pearson Products Moment Correlation Coefficient (PPMCC = r), shows the scores of ten (10) JSS I pupils [boys (x) and girls (y)] in week two VO<sub>2</sub> max exercise using the Cooper-12-minutes aerobic run test.**

Age	VO <sub>2</sub> max. for Boys (x)	VO <sub>2</sub> max. for Girls (y)	x <sup>2</sup>	y <sup>2</sup>	Xy
10-11	41.2	39.5	1697.44	1560.25	1627.4
11-12	39.4	39.5	1552.36	1560.25	1556.3
12-13	41.2	39.5	1697.44	1560.25	1627.4
13-14	41.2	39.5	1697.44	1560.25	1627.4
14-15	41.2	39.5	1697.44	1560.25	1627.4
*Σ	<b>204.2</b>	<b>197.5</b>	<b>8342.12</b>	<b>7801.25</b>	<b>8065.9</b>
*(Σx) <sup>2</sup> = 41697.64		*(Σy) <sup>2</sup> = 39006.25		*r = 0.0000 *c = 0.8783	

**Table V: Dependent T-test (t) shows the scores of ten (10) JSS II pupils [boys (x) and girls (y)] in week two VO<sub>2</sub> max exercise using the Cooper-12-minutes aerobic run test.**

Age	VO <sub>2</sub> max. for Boys (x)	VO <sub>2</sub> max. for Girls (y)	D	D <sup>2</sup>
11-12	46.5	44.7	1.8	3.24
12-13	46.5	43.9	2.6	6.76
13-14	48.3	45.6	2.7	7.29
14-15	48.3	46.5	1.8	3.24
15-16	48.3	46.5	1.8	3.24
*Σ			<b>10.7</b>	<b>23.77</b>
*(ΣD) <sup>2</sup>			<b>114.49</b>	
*t-value = 10.249		*c-value = 2.776		

**Table VI: Dependent T-test (t) shows the scores of ten (10) JSS III pupils [boys (x) and girls (y)] in week two VO<sub>2</sub> max exercise using the Cooper-12-minutes aerobic run test**

Age	VO <sub>2</sub> max. for Boys (x)	VO <sub>2</sub> max. for Girls (y)	D	D <sup>2</sup>
12-13	55.4	37.7	17.7	313.29
13-14	55.4	43.9	11.5	132.25
14-15	55.4	48.3	7.1	50.41
15-16	57.2	51.0	6.2	38.44
16-17	57.2	53.6	3.6	12.96
*Σ			<b>46.1</b>	<b>547.35</b>
*(ΣD) <sup>2</sup>			<b>2125.21</b>	
*t-value = 3.728		*c-value = 2.776		

**Table VII: Dependent T-test (t) shows the scores of ten (10) JSS I pupils [boys (x) and girls (y)] in week three VO<sub>2</sub> max exercise using the Cooper-12-minutes aerobic run test**

Age	VO <sub>2</sub> max. for Boys (x)	VO <sub>2</sub> max. for Girls (y)	D	D <sup>2</sup>
10-11	46.5	44.7	1.8	3.24
11-12	46.5	44.7	1.8	3.24
12-13	46.5	46.5	0.0	0.00
13-14	50.1	47.4	2.7	7.29
14-15	50.1	47.4	2.7	7.29
			<b>9.0</b>	<b>21.06</b>
			<b>81</b>	
	<b>*t-value = 3.652</b>		<b>*c-value = 2.776</b>	

**Table VIII: Dependent T-test (t) shows the scores of ten (10) JSS II pupils [boys (x) and girls (y)] in week three VO<sub>2</sub> max exercise using the Cooper-12-minutes aerobic run test**

Age	VO <sub>2</sub> max. for Boys (x)	VO <sub>2</sub> max. for Girls (y)	D	D <sup>2</sup>
11-12	49.2	47.4	1.8	3.24
12-13	49.2	48.3	0.9	0.81
13-14	52.8	49.2	3.6	12.96
14-15	52.8	51.0	1.8	3.24
15-16	52.8	51.0	1.8	3.24
			<b>9.9</b>	<b>23.49</b>
			<b>98.01</b>	
	<b>*t-value = 2.093</b>		<b>*c-value = 2.776</b>	

**Table IX: Independent T-test (t) shows the scores of ten (10) JSS III pupils [boys (x) and girls (y)] in week three VO<sub>2</sub> max exercise using the Cooper-12-minutes aerobic run test**

Age	(f)	(x)	(y)	f(x)	f(y)	(x-X)	(y-Y)	(x-X) <sup>2</sup>	(y-Y) <sup>2</sup>	f(x-X) <sup>2</sup>	f(y-Y) <sup>2</sup>
12-13	12.5	55.4	43.9	692.5	548.8	-3	-7	9	49	112.5	612.5
13-14	13.5	56.3	51.8	760.1	699.3	-2.1	0.9	4.41	0.81	59.5	10.9
14-15	14.5	59.8	51.9	867.1	752.6	1.4	1.0	1.96	1.0	28.4	14.5
15-16	15.5	59.8	52.8	926.9	818.4	1.4	1.9	1.96	3.61	30.4	56.0
16-17	16.5	59.8	52.8	986.7	871.2	1.4	1.9	1.96	3.61	32.3	59.6
* $\Sigma$	<b>72.5</b>			<b>4233.3</b>	<b>3690.3</b>					<b>263.1</b>	<b>753.5</b>
				<b>*t-value = 4.507</b>						<b>*c-value = 2.306</b>	

**Table X: Independent T-test (t) shows the scores of ten (10) JSS I pupils [boys (x) and girls (y)] in week four VO<sub>2</sub> max exercise using the Cooper-12-minutes aerobic run test**

Age	(f)	(x)	(y)	f(x)	f(y)	(x-X)	(y-Y)	(x-X) <sup>2</sup>	(y-Y) <sup>2</sup>	f(x-X) <sup>2</sup>	f(y-Y) <sup>2</sup>
10-11	10.5	53.6	52.8	562.8	554.4	-2.7	-2.2	7.29	4.84	76.55	50.82
11-12	11.5	54.5	55.4	626.8	637.1	-1.8	0.4	3.24	0.16	37.26	1.84
12-13	12.5	56.3	55.4	703.8	692.5	0.0	0.4	0.0	0.16	0.0	2.0
13-14	13.5	56.3	55.4	760.1	747.9	0.0	0.4	0.0	0.16	0.0	2.16
14-15	14.5	59.8	55.4	867.1	803.3	3.5	0.4	12.25	0.16	177.63	2.32
* $\Sigma$	<b>62.5</b>			<b>3520.6</b>	<b>3435.2</b>					<b>389.94</b>	<b>59.14</b>
				<b>*t-value = 1.084</b>						<b>*c-value = 2.306</b>	

**Table XI: Independent T-test (t) shows the scores of ten (10) JSS II pupils [boys (x) and girls (y)] in week four VO<sub>2</sub> max exercise using the Cooper-12-minutes aerobic run test**

Age	(f)	(x)	(y)	f(x)	f(y)	(x-X)	(y-Y)	(x-X) <sup>2</sup>	(y-Y) <sup>2</sup>	f(x-X) <sup>2</sup>	f(y-Y) <sup>2</sup>
11-12	11.5	59.8	56.3	687.7	647.5	-2.1	-1.9	4.41	3.61	50.72	41.52
12-13	12.5	59.8	55.4	747.5	692.5	-2.1	-2.6	4.41	6.76	55.13	84.5
13-14	13.5	62.5	58.9	843.8	795.2	0.6	0.7	0.36	0.49	4.86	6.62
14-15	14.5	63.4	59.8	919.3	867.1	1.5	1.6	2.25	2.56	32.63	37.12
15-16	15.5	63.4	59.8	982.7	926.9	1.5	1.6	2.25	2.56	34.88	39.78
*Σ	67.5			4181.0	3929.2					178.22	209.44
				*t-value = 3.459				*c-value = 2.306			

**Table XII: Independent T-test (t) shows the scores of ten (10) JSS III pupils [boys (x) and girls (y)] in week four VO<sub>2</sub> max exercise using the Cooper-12-minutes aerobic run test**

Age	(f)	(x)	(y)	f(x)	f(y)	(x-X)	(y-Y)	(x-X) <sup>2</sup>	(y-Y) <sup>2</sup>	f(x-X) <sup>2</sup>	f(y-Y) <sup>2</sup>
12-13	12.5	62.5	57.2	781.25	715.0	-8.1	-6.7	65.61	44.89	820.13	561.13
13-14	13.5	64.3	58.0	868.05	783.0	-6.3	-5.9	39.69	34.81	535.82	469.94
14-15	14.5	67.0	58.0	971.5	841.0	-3.6	-5.9	12.96	34.81	187.92	504.75
15-16	15.5	67.0	61.6	1038.5	954.8	-3.6	-1.4	12.96	16.81	200.88	260.56
16-17	16.5	67.0	61.6	1105.5	1016.4	-3.6	-1.4	12.96	16.81	213.84	277.2
*Σ	67.5			4764.8	4310.2					1958.6	2073.6
				*t-value = 1.542				*c-value = 2.306			

## Discussion of Findings

Maximum oxygen uptake capacity (VO<sub>2</sub> max) has been widely considered to be reliable and valid measure of cardio respiratory fitness (Das & Dhundasi, 2001). The result of the maximum volume of oxygen (VO<sub>2</sub> max) rate in the above investigation shows an insignificantly low VO<sub>2</sub> max in the beginning of the session between boys and girls as shown in tables I, II and III.

This study mainly shows that maximum oxygen uptake (VO<sub>2</sub> max) is known to be significantly correlates with age. As suggested by Astrand and Rodhal

(1986), that maximum oxygen uptake increases with age up to 20 years. Hence, there is a gradual decline in maximum oxygen uptake. Hagen *et al.* (1993) and Biswas *et al.* (2004) also suggested the same view, which state that the decrease of maximal volume of oxygen uptake corresponds to the advancement of age. The Pearson Product Moment Correlation (PPMC) Coefficient, Dependent and Independent t-tests were used to compare the results of the study. The results were tested at ( $p \leq 0.05$ ) level of significance. Analysis of results from weeks one, two, three and four shows both significance and insignificance differences between the measurement level of VO<sub>2</sub> max rate of

boys and that of girls (JSS I, II & III) at the beginning and at the end of the exercise which is recorded as r values [(i.e. r values ranging from  $r = 0.0000$  to  $r = 0.7442$ ) when compare with the c value (i.e. c value = 0.8783)] as shown in tables I, II, III and IV; and as t values [(i.e. t values ranging from  $t = 10.249$  to  $t = 3.728$ ) when compared with the dependents and independent c values ( $c = 2.776$  and  $c$ -value = 2.306)] as shown in tables V, VI, VII, VIII, IX, X, XI and XII.

In the concluded investigation analysis above, age was observed to have a significant relationship with the VO<sub>2</sub> max in both boys and girls. *Biswas et al. (2004)* also noted similar type of observation. This study also found that there is a very high correlation between the distances someone can run in 12 minutes and their VO<sub>2</sub> max value. The correlation coefficient between VO<sub>2</sub> max and 12 minutes run distance in the above investigation shows r values range from ( $r = 0.0000$ ) to ( $r = 0.7442$ ), and dependent and independent t values range from ( $t = 10.249$ ) to ( $t = 3.728$ ) in case of both boys and girls within the age range of 10 – 17 years at JSS level. However, Cooper in 1968 observed that the result of correlation coefficient was 0.90 with an age range of 17 – 54 years.

*Conclusion:* Based on the findings of the study, it concluded that high level of physical fitness requires a high VO<sub>2</sub> max value. The above findings further concluded therefore that, boys have slightly or equal cardiorespiratory fitness level when compared to girls due to slight significant or insignificant levels recorded at  $p \leq 0.05$  during the analyses of their VO<sub>2</sub> max status in 12 minutes run cooper test with regards their age bracket and class level. The study also concluded that significant correlation coefficient was found between age bracket and VO<sub>2</sub> max value in both boys and girls. Since oxygen is ultimately consumed in the muscles during exercise, it follows that the VO<sub>2</sub> max, when measured, will vary in accordance with the specific form of exercise performed or a total distance covered as in this study with the cooper 12-minutes run test.

In addition, the major finding in this study shows that pupils (boys and girls) were experiencing quick fatigue at the beginning of the exercise which affected the low rate of their VO<sub>2</sub> max calculation greatly but they had to overcome the fatigue as the session continued into the subsequent weeks thereby improving their rate.



**Recommendations:** In recommendation, the basic aerobic endurance training is usually sufficient for children especially at junior secondary school level. The most effective approach to improving VO<sub>2</sub> max is by applying the endurance high intensity interval training (HIIT), Tabata, Izumi; Irisawa, Kouichi; Kouzaki, Motoki; Nishimura, Kouji; Ogita, Futoshi; & Miyachi, Motohiko (1997). This can be implemented in schools during Physical Education lessons, thereby allotting enough time on the teaching time table for Physical Education and also to encourage more professionals of Physical Education be trained and employed to teach the subject in schools for children to reap the full benefits of improved VO<sub>2</sub> max for physical fitness and sports training.

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