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Assessment of Cardiorespiratory Fitness among School-Aged Adolescents in Selected Schools of a Nigerian City

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Abstract. Low level of cardiorespiratory fitness has been shown to increase the risk factors for non-communicable chronic diseases in adults and adolescents, and has been proven to result in early death especially in Nigeria. The study assessed cardiorespiratory fitness among school-aged adolescents and determine the relationship among the various anthropometric variables. The cross-sectional survey recruited 236 apparently healthy participants ranging from 13 to 18 years purposively from public and private secondary schools in Ile-Ife, Nigeria. Selected anthropometric variables of weight, height, waist and hip circumference of the participants were measured using standard procedures. Six Minutes Walk Test (SMWT) was conducted to assess cardiorespiratory fitness by using maximal oxygen uptake in VO_2max for each participant. Data were analyzed using descriptive and inferential statistics. Alpha level was set at <0.05. The result shows that the mean value of the participants' age was 15.50± 1.5 years, the mean body mass index was 19.83±2.79 kg/m^2 and the mean Cardiorespiratory Fitness (CRF) was 31.85±4.26 mLkg^{-1}·min^{-1}· Fitness. The mean CRF for males and females of 13 years old was 31.09±4.54 mLkg^{-1}·min^{-1}, and 32.97±4.16 mLkg^{-1}·min^{-1}, respectively and that of 18 years old was 33.51±3.98 mLkg^{-1}·min^{-1} and 32.63±0.73 mLkg^{-1}·min^{-1}, respectively. The male cardiorespiratory fitness was found significantly higher (t=3.32, p<0.001) compare to the female values. Cardiorespiratory fitness showed a significant correlation with ages (r=0.21, p=0.000) and height (r=0.16, p=0.01). In conclusion, the cardiorespiratory fitness of adolescent in the study was of lower value compared to the standard, age wise and male cardiorespiratory fitness was more than that of female.
Key words: *cardiorespiratory fitness, adolescents, male, female, VO_2 max.*

Introduction

Physical activity has been reported to be absolutely critical to the general well-being of the body. Its increase was found to be associated with improved cardiorespiratory status minimizing the risk factors for non-communicable chronic diseases (1, 2). Advance in technology, urbanization and mechanization had created a great threat to the level of physical activity around the world for which at any age individuals are now at risk of chronic health problems including cardiovascular diseases (3).

Childhood and adolescence are crucial periods of life, since dramatic physiological changes take place at these ages (4). Likewise, lifestyle and healthy/unhealthy behaviors are established during these years which may influence adult behavior and health status (5). Cardiorespiratory fitness (CRF) is a health-related component of physical fitness and it is the ability to perform day to day bodily work without hurting the biological or psychosocial health (6,7). Adolescents were classified into two levels-meeting or not meeting the CRF standards-based on the FITNESSGRAM standards for Healthy Fitness Zone, which correspond to ≥ 42 mLkg^{-1}·min^{-1} in boys and to ≥ 37.0 mLkg^{-1}·min^{-1} among 12-yr-old girls and to ≥ 35.0 mLkg^{-1}·min^{-1} in ≥ 14-yr-old girls. Report showed a decrease in the average values of CRF in students from several countries (8,9,10). Hence, the low levels of cardiorespiratory fitness in childhood and adolescence are associated with an increased early death due to any cause especially cardiovascular diseases (11).

Thorough reviews have recently discussed the associations between cardiorespiratory fitness at young ages and its short/long term consequences on health (12). Among children and adolescents, cardiovascular diseases risk status has been positively associated with obesity and inversely associated with higher levels of CRF, even after accounting for the effect of body fat (13). He et al, in his study showed that low CRF values are positively associated with an overweight and sedentary life style (15). A serial cross-sectional study conducted by Stratton et al, between 1998 and 2004 on CRF and Body Mass Index among British children found out that they had increased BMI and decreased CRF (16). There is paucity of data on the cardiorespiratory fitness of adolescents in Nigeria especially in Ile Ife.

Thus, the study assessed cardiorespiratory fitness and selected anthropometric variables (weight, height, waist circumference and hip circumference) among school-aged adolescents in Ile-Ife, Osun State Nigeria and determined the relationship between them.

Material and Method

A cross-sectional survey study was conducted among secondary school students. Non-probability purposive sampling technique was used to select 236 (124 males and 112 females) apparently healthy students ranging from 13-18 years.

Research instruments were: Portable bathroom weighing scale - Hanson bathroom scale (made in China), calibrated from 0-120kg was used to measure body weight to the nearest kilogram; Inelastic tape measure (Butterfly model-made in China), graduated in centimeters from 0-150, used to measure the hip and the waist circumference.

Procedures. Ethical approval was obtained from the Health Research and Ethics Committee (HREC) of the Institute of Public Health, Obafemi Awolowo University, Ile-Ife (IPH OAU), Nigeria. A letter of introduction was obtained from the Department of Medical Rehabilitation (to the head teachers and principals of schools that was recruited in the study. Permission was obtained from the class teachers and from the participant's parents.

Anthropometric measurement: height, weight, waist and hip circumference of participants were measured using the procedures according to Marfell-Jones et al. (17). The selected anthropometric indices and CRF were assessed and measured with their ages recorded as well.

Six Minutes Walk Test (SMWT) was used as the exercise protocol. The total number of distances covered during the walk test was recorded and from it the speed of participants was calculated which was inputted into the American College of Sport Medicine (ACSM) walking equation to determine the value of cardiorespiratory fitness of the participants in VO_2max ($mL.kg^{-1}.min^{-1}$):

VO_2max ($mL.kg^{-1}.min^{-1}$) = (0.1 X S) + (1.8 X S. G) + 3.5 $mL.kg^{-1}.min^{-1}$ (where: S = Speed in $m.min^{-1}$, G = percentage grade (% incline) incline of the walking surface, G is taken to be 2% inclination).

Data Analysis. Descriptive statistics of frequency, percentage, mean and standard deviation was used to summarize the data. Independent t-test was used to determine the difference between the variables of the male and female participants, Pearson's Product Moment Correlation was used to show the relationship between Cardiorespiratory Fitness and other anthropometric variables of the participants. Regression analysis was used to determine the predictive equation for the cardiorespiratory fitness. The level of significance set at alpha = 0.05.

Results

Two hundred and thirty-six participants (52.5% males and 47.5% females) with mean age and age range of 15.50±1.50 years and 13-18 years, respectively, participated in this study.

The mean cardiorespiratory fitness of participants is 31.85±4.26 $mLkg^{-1}min^{-1}$. The other physical characteristics are presented in Table I.

The data presented in Table II and Table III is the obtained cardiorespiratory fitness in VO_2max and the recommended values of male and female participants, respectively. The mean cardiorespiratory fitness for the age of 13, 15 and 18 years were 31.09± 4.54 $mLkg^{-1}min^{-1}$, 32.17±3.41 $mLkg^{-1}min^{-1}$ and 33.51±3.98 $mLkg^{-1}min^{-1}$ respectively.

While that of female were 32.97±4.16 $mLkg^{-1}min^{-1}$, 30.81±3.66 $mLkg^{-1}min^{-1}$ and 32.63±0.73 $mLkg^{-1}min^{1}$, respectively. However, these values were found lower than the recommended values. The mean cardiorespiratory fitness of male and female participants for the respective ages were lower than the FITNESSGRAM healthy fitness zone.

Table I. Physical characteristics of participants (n=236)

Variables	Minimum	Maximum	Mean±SD
Age(years)	13.00	18.00	15.50±1.50
Weight(kg)	31.00	100.00	51.61±9.42
Height(m)	1.34	1.86	1.61±0.91
WC (cm)	52.00	92.00	67.55±6.49
HC (cm)	62.00	104.00	80.73±7.61
BMI (kg/m^3)	11.42	32.46	19.83±2.79
WHR	0.73	1.15	0.84±0.50
SPEED(m/min)	83.67	237.50	149.22±22.42
CRF ($mLkg^{-1}\cdot min^{-1}$)	19.40	48.63	31.85±4.26

Table II. Obtained cardiorespiratory fitness in VO_2max of male participants and health fitness zone values according to ages

Ages	Minimum	Maximum	Mean±SD	HFZ of FITNESSGRAM
13yrs	20.30	36.80	31.09±4.54	≥41.1
14yrs	19.40	40.55	30.43±4.94	≥42.5
15yrs	24.80	36.80	32.17±3.41	≥43.6
16yrs	25.38	40.58	32.69±4.29	≥44.1
17yrs	21.60	40.60	33.22±3.96	≥44.2
18yrs	24	40.10	33.51±3.98	≥44.3

Key: HFZ= Health fitness zone; *Note:* The Health Fitness Zone Values was adapted from "FITNESSGRAM Healthy Fitness Zone Performance Standards". Copyright 2017 by California Department of Education.

Table III. Obtained cardiorespiratory fitness of female participants and health fitness zone values according to ages

Ages	Minimum	Maximum	Mean±SD	HFZ of FITNESSGRAM
13yrs	28	35.50	32.97±4.16	≥39.7
14yrs	22.50	34.85	30.92±2.16	≥39.4
15yrs	22.80	38.70	30.81±3.66	≥39.1
16yrs	22.50	48.63	31.03±5.09	≥38.9
17yrs	28.33	39.19	34.07±3.53	≥38.8
18yrs	32.00	33.43	32.63±0.73	≥38.8

Key: *HFZ= Health fitness zone: The Health Fitness Zone Values was adapted from "FITNESSGRAM Healthy Fitness Zone Performance Standards". Copyright 2017 by California Department of Education.*

In the Table IV is showed the comparison between male and female anthropometric variables and the cardiorespiratory fitness. There was significant differences between male and female's weight (t=3.111, p=0.001), waist circumference (t=-2.617, p=0.009), waist to hip ratio (t=4.47, p=0.001) speed (t=3.317, p= 0.001) and cardiorespiratory fitness (t=3.32, p=0.000)

Table IV. Independent sample t-test of comparison of male and female cardiorespiratory fitness (n = 236)

Variables	**Male=124** (mean±SD)	**Female=112**(mean±SD)	t-value	p-value
Height/m	1.64+0.9	1.57±0.07	6.010	0.001
Weight/kg	53.38+10.88	49.65±10.02	3.111	0.002*
BMI/kgm^{-2}	19.68+3.03	19.99±2.99	-.848	0.374*
WC/cm	66.50+6.32	68.69±5.57	-2.617	0.009*
HPC/cm	78.19+6.42	83.55±7.85	-5.719	0.001*
WHR	0.85+.05	0.84±0.04	4.47	0.001*
Dis/m	922.36+137.02	865.04±125.06	3.37	0.001*
Speed/m^{-2}	153.72+22.8	144.23±20.9	3.317	0.001*
CRF(VO_2max)	32.71±4.34	30.90±3.98	3.32	0.000*

*Key *p< 0.05. BMI = Body Mass Index, WC = Waist circumference, HPC = Hip Circumference, WHR = Waist to hip ratio, Dis = Distance, CRF = Cardiorespiratory response.*

The results further showed a significant correlation between cardiorespiratory fitness and each of participant's age (r=0.21, p=0.000) and height (r=0.16, p=0.01). This was illustrated in Table V.

Table V. Relationship between cardiorespiratory fitness, age and selected anthropometric indices (n=236)

Variables	r-value	p-value
Age(yrs)	0.21	0.00*
Weight(kg)	0.31	0.64
Height(m)	0.16	0.01*
Hip circumference(cm)	0.07	0.30
Waist circumference(cm)	0.05	0.47
Body mass index(kg/m^2)	-0.11	0.11
Waist to hip ratio	-0.02	0.73

*p < 0.05

Discussion

The major findings of this study were that the mean value of cardiorespiratory fitness (CRF) of participants was lower than the recommendation of FITNESSGRAM Healthy Fitness Zone. The optimum level for male and female adolescents for the healthy fitness zone of the FITNESSGRAM falls between 41 and 44.5 mLkg^{1}min^{-1} and between 38 and 40 mLkg^{-1}min^{-1}, respectively. A mean value between 30.90±3.98 mLkg^{-1} min^1 was observed for female adolescents in our study while that of male was observed to be 32.71±4.34 mLkg^{1}min^{-1}. This indicates that participants in this study may be predisposed to cardiovascular disease later in life.

This supports a systematic review by (18) which reported a significant association between cardiorespiratory fitness and cardiovascular disease risk factors in adolescents, a lower CRF was associated with higher future cardiovascular disease risk factors. The lower in CRF in our environment and in the nation generally may be due to the technology advancement and its effect on human population. Proliferation of automobiles has reduced drastically the early walking exercises of adolescents to the schools. Emergency of telecommunication as well has abated the errand running of children especially inter and intra community which usually enhances the physical activities of adolescent. More importantly, the advent of home videos and televisions has hampered the physical activities of both the young and old ones in that individuals can sit down watching a play or film for several hours, thereby burning out the whole days with no physical activity.

The current study also found out that mean values of cardiorespiratory fitness in VO_2max were higher in male than in female. This is consistent with the work of Demirkan et al, Heroux et al, and Tanha et al, which found out that VO_2max mean values in male adolescents are higher than in female adolescents (19-21).

Factors that may contribute to higher VO_2max in male adolescents are lean body mass and gender (19). In terms of gender, studies have shown that VO_2max in female adolescents increases slowly compared to that of male of the same age during puberty V (19, 22). Hence, changes in body physiology and differences during sexual maturation might influence cardiorespiratory fitness especially of female individuals (19). More so, the study found that male anthropometric parameters in terms of height, weight, waist circumferences and others were significantly higher in values for males than that of females. Among humans, there has been a report of marked difference in body composition in males and females which includes both size and shape (23). Literature has established that adult females surpass males in the amount of subcutaneous fat tissue and a quantitative higher amount of fat free body mass including bone and soft tissue lean body mass that is muscle mass was exhibited in male throughout adult life (23,24). These are reasons male anthropometric variables were found to be more than female values in our study.

It was also observed that there was a positive relationship between age and cardiorespiratory fitness. This is in contrast with the study of Olawale et al., which observed that there was no relationship between age and cardiorespiratory fitness among adolescents (25). However, there was a significant relationship between cardiorespiratory fitness and height in this study, which is consistent with the study of Chatterjee et al, who found a relationship between the body height and cardiorespiratory fitness (VO_2max) of 129 children aged 8-20 years (26).

The significant relationship between height and cardiorespiratory fitness (VO_2max) can related to the fact increase in tall individuals have an increase lean body mass and long enlarged lungs which enhances increase in lung capacity higher maximum oxygen consumption (27).

Conclusion

Based on the findings of this study, it was concluded that participants of this research had a lower cardiorespiratory fitness compared to the recommended values of FITNESSGRAM for the healthy fitness zone. However, male participants of the study had a significantly higher cardiorespiratory fitness than the female participants.

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