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RESEARCH ARTICLE

Does visceral fat affect aerobic fitness in Indian adolescents of 18-19 years' age group?

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ABSTRACT

Background: Cardiovascular endurance tests are considered as one of the best methods for assessment of the individual's health. Reduced aerobic fitness is seen in overweight and obese. Aerobic fitness is also reduced in centrally obese individual. However, very less scientific documentation available on the effect of visceral fat on aerobic fitness in Indian adolescents. **Aims and Objectives:** The present study was undertaken to check the effect of visceral fat on aerobic fitness in Indian adolescents of 18-19 years of age group. **Materials and Methods:** Our study was conducted on 120 healthy, non-athletes' Indian adolescents (60 males and 60 females) of 18-19 years of age group after their voluntary written consent. Visceral fat was recorded by bioelectrical impedance technique using Omron HBF-302 body fat analyzer. All volunteers were categorized into two groups on the basis of their visceral fat. Volunteers with visceral fat 0-9 were categorized as a normal visceral fat group, and volunteers with visceral fat ≥10 were categorized as a high visceral fat group. Estimation of VO_2max was done by treadmill exercise test following the standard Bruce protocol. **Results:** In high visceral fat Indian adolescents, VO_2max by treadmill exercise test was significantly less as compared to the normal visceral fat group. In normal visceral fat male adolescents ($n = 30$), VO_2max was 49.29 ± 7.81 ml/kg/min, and in high visceral fat male adolescents ($n = 30$), VO_2max was 33.94 ± 6.75 ml/kg/min. ($P < 0.001$). Similarly, in normal visceral fat female Indian adolescents, VO_2max was 47.85 ± 7.10 ml/kg/min, whereas in high visceral fat female adolescents ($n = 30$), VO_2max was 29.68 ± 7.79 ml/kg/min. ($P < 0.001$). **Conclusion:** VO_2max was significantly less in high visceral fat adolescents compared to normal visceral fat adolescents. Increased visceral fat is associated with reduced aerobic fitness in Indian adolescents.

KEY WORDS: Visceral Fat; Aerobic Fitness; Predicted VO_2max; Bruce Protocol; Indian Adolescents

INTRODUCTION

Cardiorespiratory fitness denotes overall physical fitness.[1] Assessment of aerobic fitness is a new trend in young individuals in developed and developing countries for assessing overall fitness. Nowadays, aerobic fitness is considered as very useful health markers. Low aerobic fitness is considered as cardiovascular risk factors which can be modified by regular physical exercise and proper diet.[2] Aerobic fitness should be assessed to check its association with various body composition parameters such as body mass, fat mass (FM), fat-free mass (FFM), and visceral FM. Reduced aerobic fitness is very well documented in overweight and obese.[2,3] Greater VO_2max is associated with lesser visceral fat and body mass index (BMI) and vice versa. Augmented aerobic fitness is supposed to improve blood pressure, cholesterol level, and status of weight in adolescents. Lesser cardiovascular

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fitness is well-known to cause cardiovascular diseases later in adulthood.[4]

Obesity is increasing significantly during the past two decades in India.[5-7] Overweight and obesity lead to approximately 2.8 million deaths in adults worldwide every year and are the fifth leading cause of mortality.[8] More than half of deaths in India occurred due to non-communicable diseases, and obesity is the root cause for so many non-communicable diseases.[9] Globally, obesity is called "New World Syndrome" which is causing severe economic and health burden on the community and the WHO defined it as a global epidemic in the past 20 years.[7,10]

Prevalence of abdominal or central obesity is more in India as compared to other countries.[11] India is facing a new problem of normal weight obesity, wherein normal-weight individual, high body fat is seen over the viscera due to a sedentary lifestyle. Nowadays, due to urbanization, high visceral fatness is a common finding in Indians. High visceral fatness is associated with increased insulin resistance, dyslipidemia, and diabetes mellitus.[12-14] It is known that visceral fatness is a main culprit for metabolic syndrome than total body fat. Central fatness arrests freedom of visceral organs, and ultimately, over a long period of time, functions of visceral organs are compromised. In adults, nearly 80% of body fat is found in subcutaneous adipose tissue and 10-20% in viscera or intra-abdominal adipose tissue.[12] Many studies have portrayed that visceral fat per se the culprit for stroke, cardiovascular diseases, and non-insulin dependent diabetes mellitus than overall obesity.[12,14-17] Excess visceral fat causes excess levels of free fatty acid and inflammatory cytokines in portal vein, which elevates the risk of metabolic syndrome.[14] In recent times, visceral obesity is deliberated as "Civilization Syndrome."[15] Moreover, it is found that adolescence is considered as one of critical time and age frames in development of obesity.[18] The adolescent period consists of growth and development physically, psychologically, and sexually, thus preparing the individual toward adulthood. Adolescents who are obese have more likelihood of becoming obese in adulthood.[19]

Association of BMI with aerobic fitness had been documented very well,[2,20] but BMI does not reflect visceral adiposity equally across populations as indicated that Asian population have a relatively higher amount of adipose mass at similar levels of BMI as compared to other populations, so it is essential to know the impact of visceral fat on aerobic fitness in Indian adolescents. Hence, the objective of this study was to know the influence of visceral fatness on aerobic fitness in Indian late adolescents of 18-19 years' age group.

MATERIALS AND METHODS

A cross-sectional study was done on 120 healthy Indian adolescents (60 males and 60 females) of 18-19 years of age group from students of various colleges after approval of the Institutional Ethics Committee. Detailed information about the study was given to all volunteers, and they were informed about the type of the study, its rationale, and related risks as well as the time required for the study. All the volunteers were enrolled in the present study after their written voluntary consent. All the volunteers were symptoms free and apparently healthy at the time of the study. Volunteers with a history of cardiovascular disease, respiratory disease, diabetes, or any other physical disability which affects the study were excluded from the study. Volunteers who were on regular physical exercises were also excluded from the study. Volunteers with the addiction of smoking, alcohol, and any other chronic diseases were also excluded from the study. Detailed history and pre-exercise heart rate and blood pressure were recorded, and those who were not suitable for the treadmill exercise test were excluded from the study.

Volunteers were given prior instructions for not engaging themselves in any unusual physical efforts for at least 12 h before testing. Volunteers were instructed to dress appropriately for exercise. They were instructed for avoiding heavy meals 3 h before the test. Volunteers were asked to avoid the intake of any stimulant (drugs, coffee, etc.) for at least 30 min before the testing. Volunteers were also asked to empty the bladder before the testing.[21,22]

Anthropometric Measurements

Anthropometric parameters were measured with least clothing and bare feet. The height was measured using a meter scale without footwear to the nearest 0.1 cm.[23] Waist circumference (WC) was measured at the midpoint between the lower costal margin and the highest point on the iliac crest to the nearest 0.5 cm at the end of normal expiration.[22] Body weight, total body fat (TBF) percentage, and visceral fat were measured by bioelectrical impedance technique using Omron HBF-302 body fat analyzer.[22] Body mass index (BMI) was calculated as the weight (kg) divided by the square of height (m^2). FM was calculated based on TBF percentage into body weight. FFM was calculated by subtracting FM from total body weight.[22] Volunteers were divided into two groups on the basis of their visceral fat. Volunteers with visceral fat 0-9 were categorized as a normal visceral fat group, and volunteers with visceral fat ≥10 was categorized as a high visceral fat group for both the genders.[23]

Calculations of VO_2max by Bruce Protocol

Estimation of maximum oxygen utilization was done using motorized treadmill machine following the standard Bruce Protocol as per proposed guidelines of the American Heart Association.[21] Bruce's treadmill exercise test is a continuous, incremental test which consists of total 7 stages, and each stage continues for 3 min. Before starting the test, 5 min of warm-up were carried at a speed of 2 km/h. Time was measured by stopwatch. During the treadmill test, exercise speed and grade are increased every 3 min. During the first stage, volunteers walk at a speed of 2.7 km/h at an incremental grade of 10%, and then, during the second stage, speed increases to 4.0 km/h at a grade of 12%.[24] Volunteers were asked to continue exercise until they reached 85% of their age-adjusted predicted maximum heart rate or develop cardiorespiratory symptoms.[24] Perceived exertion was recorded using Borg's scale.[21] At the end of exercise, the total duration of exercise was recorded in minutes and seconds, and on the basis of exercise time (T), VO_2max was calculated by following formula in males and females' separately.[25,26]

$$\text{Male} = 14.76 - (1.379 \times T) + (0.451 \times T^2) - (0.012 \times T^3)$$

$$\text{Female} = (4.38 \times T) - 3.9.$$

Statistical Analyses

All the physiological variables were presented as mean ± standard deviation. Independent sample *t*-test was used to check the significant difference between normal visceral fat group and high visceral fat group. A $P < 0.05$ was considered statistically significant.

RESULTS

Descriptive characteristics of Indian adolescents were shown in Table 1. Males were younger in age and taller than females. BMI, TBF percentage, FM, FFM, and total exercise time were statistically significant between groups ($P < 0.05$). Weight, WC, visceral fat level (VFL), and VO_2max (VO_2max value obtained by treadmill exercise test following Bruce protocol) were similar in both the genders.

As per Table 2, male adolescents were categorized into two groups: Normal visceral fat group (VF from 0 to 9) and high visceral fat group (VF from ≥10). They were similar in age and height. Body composition parameters such as body weight, FM, FFM, BMI, WC, and VFL were more in the high visceral fat group as compared to normal visceral fat group of male Indian adolescents, and they were statistically highly significant ($P < 0.001$). In normal visceral fat male Indian adolescents ($n = 30$), VO_2max value obtained by treadmill exercise test following Bruce protocol was 49.29 ± 7.81 ml/kg/min, whereas in high visceral fat males ($n = 30$), it was 33.94 ± 6.75 ml/kg/min. VO_2max was more in normal visceral fat males as compared to high visceral fat males, and it was statistically significant ($P < 0.001$).

As per Table 3, body weight FM, FFM, BMI, WC, and VFL were more in high visceral fat Indian adolescent females as compared to normal visceral fat group. In normal visceral fat Indian adolescent females ($n = 30$), VO_2max value obtained by treadmill exercise test following Bruce protocol was 47.85 ± 7.10 ml/kg/min, whereas in high visceral fat females ($n = 30$), it was 29.68 ± 7.79 ml/kg/min. VO_2max was more in normal visceral fat females as compared to high visceral fat females, and it was statistically significant ($P < 0.001$).

Table 1: Basic characteristics of subgroup of adolescents

Variables	Mean±SD		*P*
	Males (*n*=60)	Females (*n*=60)	
Age (years)	18.16±0.37	18.56±0.49	<0.001
Height (m)	1.70±0.057	1.53±0.067	<0.001
Weight (kg)	73.81±17.16	69.95±17.87	0.230
FM (kg)	18.24±9.22	25.38±9.99	<0.001
FFM	55.56±8.54	44.56±8.21	<0.001
BMI (kg/m^2)	25.30±5.50	28.56±6.69	0.004
TBF percentage	23.32±7.01	35.02±5.92	<0.001
WC (cm)	89.30±15.85	88.92±13.60	0.887
VFL	8.55±5.60	9.3±6.31	0.180
Total exercise time (min)	11.75±2.68	9.74±2.68	<0.001
VO_2max*(ml/kg/min)	41.62±10.59	38.76±11.77	0.165

*VO_2max predicted maximum oxygen consumption during Bruce protocol. FM: Fat mass, FFM: Fat-free mass, BMI: Body mass index, TBF: Total body fat, WC: Waist circumference, VFL: Visceral fat level, SD: Standard deviation

Table 2: Basic characteristics of Indian male adolescents

Variables	Normal VF group (*n*=30)	High VF group (*n*=30)	*P*
Age (year)	18.1±0.30	18.23±0.43	0.171
Height (m)	1.70±0.062	1.71±0.051	0.700
Weight (kg)	60.10±8.15	87.51±11.99	<0.001
FM (kg)	11.07±4.42	25.41±6.85	<0.001
FFM (kg)	49.02±5.17	62.09±5.79	<0.001
BMI (kg/m^2)	20.73±2.31	29.86±3.63	<0.001
TBF percentage	18.02±5.24	28.63±3.78	<0.001
WC (cm)	75.8±6.84	102.81±9.31	<0.001
VFL	3.96±2.14	13.13±3.98	<0.001
Total exercise time (min)	13.65±1.91	9.86±1.89	<0.001
VO_2max (ml/kg/min)	49.29±7.81	33.94±6.75	<0.001

FM: Fat mass, FFM: Fat-free mass, BMI: Body mass index, TBF: Total body fat, WC: Waist circumference, VFL: Visceral fat level

DISCUSSION

The present study showed that increased visceral fat accumulation is linked with reduced aerobic fitness in Indian adolescents of 18-19 years of age group. As per Tables 2 and 3, height and age were similar between normal visceral fat and high visceral fat adolescents of both the genders. Body mass, FM, and FFM were more in the

Table 3: Basic characteristics of Indian female adolescents

Variables	Normal VF group (*n*=30)	High VF group (*n*=30)	*P*
Age	18.53±0.50	18.60±0.49	0.609
Height (m)	1.56±0.065	1.56±0.070	0.733
Weight (kg)	55.01±7.43	84.90±11.50	<0.001
FM (kg)	16.94±4.48	33.83±5.94	<0.001
FFM	38.06±3.84	51.06±5.92	<0.001
BMI (kg/m^2)	22.74±3.51	34.37±2.95	<0.001
TBF percentage	30.36±4.71	39.69±2.01	<0.001
WC (cm)	77.55±7.59	100.30±7.15	<0.001
VFL	3.93±2.27	14.66±4.04	<0.001
Total exercise time (min)	11.81±1.62	7.66±1.78	<0.001
VO_2max (ml/kg/min)	47.85±7.10	29.68±7.79	<0.001

FM: Fat mass, FFM: Fat-free mass, BMI: Body mass index, TBF: Total body fat, WC: Waist circumference, VFL: Visceral fat level

high visceral fat group as compared to normal visceral fat Indian adolescents. Males with normal visceral fat group were able to do exercise for a longer time compared to a high visceral fat group. The high visceral fat group having lesser VO_2max as compared to a normal visceral fat group of male adolescents. Females with high visceral fat group were able to do exercise for a lesser time compared to a normal visceral fat group of female adolescents. Females with normal visceral fat had higher VO_2max as compared to a high visceral fat group. ($P < 0.001$).

VO_2max gives highly advantageous information regarding oxygen delivery to exercising muscles. In healthy individuals, VO_2max differs with age, gender, and by anthropological parameters. Association of VO_2max with body mass is very well documented by scientist.[2,20,27] Chatterjee et al. had documented body mass as predictor of VO_2max. Aerobic fitness is reducing in overweight and obese individuals.[27] BMI is the most commonly used tool to judge the nutritional status of individual and overall fitness.[27,28] Body mass which includes FM and lean body mass (FFM) does not reflect the central or peripheral obesity. FM, FFM, and visceral FM are different in persons with normal body mass and in overweight and obese. Body composition parameters are different in normal healthy individuals. Oda et al. (2014) reported the relationship between peak oxygen consumption and regional body composition in Japanese subjects.[28] Watanabe et al. reported the negative association of body fat percentage with maximal oxygen uptake in small sample study.[29] Sanada et al. showed a positive association of skeletal muscle mass with ventilatory threshold and peak oxygen utilization in Japanese men and women.[30] Our study findings were supported recently by Lesser et al. (2015) who showed a negative association of visceral FM with VO_2max in South Asian postmenopausal women.[31] Haufe et al. (2010) and Janssen et al. (2004) also had documented higher cardiorespiratory fitness in men and women with lowest visceral adipose tissue.[32,33] Salehi et al. (2014) had documented positive association of VO_2max with muscle mass, but no relation with visceral FM was seen in their studies.[34] Body composition influenced maximal oxygen uptake during treadmill exercise testing. Peak workload-bearing capacity is different in individual with visceral FM, total body FM, and muscle mass. Mechanical efficiency is decreased in persons with high visceral fat due to the requirement of extra energy to facilitate associated body movements. Anton-Kuchly et al. documented the use of more energy by obese individuals as compared to lean individuals.[35] de Souza e Silva et al. (2016) currently studied on the influence of central obesity in estimating VO_2max and established that central obesity diminishes VO_2max. However, they have used waist-to-height ratio which is a measure of central obesity than visceral fatness.[36] Exercise performing ability is significantly decreased in persons with central or peripheral fatness. Supply of oxygen to the working muscles is reduced in overweight and obese due to fatness. Physical inactivity is the key factor for the accumulation of fat over abdominal region, and if proper care is not taken, it leads to visceral or central obesity. Regular physical activity plays a key role in the prevention of cardiovascular diseases as well all-cause mortality.[33,37] Stevens et al. reported interrelation of fitness and body mass with cardiovascular mortality. Prevention of visceral fatness by doing regular physical exercise is very useful remedy for prevention of non-communicable diseases and for good aerobic fitness.[24]

In our study, we have estimated that VO_2max by treadmill exercise stress test following Bruce Protocol is the strength of the study. In our study, total exercise time during treadmill exercise test was taken for the calculation of equation-based predicted VO_2max following Bruce protocol rather than using body age, BMI, TBF percentage, and physical activity level. The limitations of the study are the estimation of VO_2max by indirect equation-based method rather than direct measurement of O_2 and CO_2 level during treadmill exercise testing. The study can be replicated with large sample size.

CONCLUSION

We conclude that aerobic fitness is less in high visceral fat Indian adolescents as compared to normal visceral fat Indian adolescents of 18-19 years of age group. In our study, female adolescents have a poor aerobic fitness compared to male adolescents. Increased visceral fat played a crucial role in the reduction of aerobic fitness. Weight reduction program and an increase in physical activity may help in younger generations for improving overall fitness and to combat the adverse effect of visceral obesity.

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