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Effect of Body Composition and Aerobic Capacity on Blood Pressure in Young Indian Adult Males of Age Group 18 -21 Years

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Abstract: ***Introduction**: Body composition refers to lean tissue mass and fat mass measured in terms of body fat percentage. Aerobic capacity refers to ability to sustain exercise tolerance measured in terms of VO2 max. Both the factors are known to affect blood pressure. But this association is less studied in Indian population. **Aim**: To study the association between body fat percentages, VO2 max and blood pressure. **Methodology**:A total of 50 healthy Indian adult male of age group 18-21 were included. Their BMI, body fat percentage and BP was measured and was evaluated for association. **Results**:The average VO2max was highest (3.9 L/min) in category with Body fat % (13-17%) and least (VO2 max 3.3 L/min) in category with Body fat % (>17%). 40 out of 50 subjects, i.e., 80% of the subjects had SBP in the range 110-130 mmHg (body fat % : 10.9%) while 6 subjects had SBP< 110mmHg (MABP: 83.8 mmHg) and an average body fat% which was lower (9.5%) and 4 subjects had a SBP of >130 mmHg (MABP: 95.3 mmHg) and higher body fat% (13.6%). **Discussion**: The VO2max was found to be highest in that category of Body fat % which ranged from 13% to 17% and was least in the category of Body fat % greater than 17%. Average Resting HR was the highest in the group of subjects that had higher body fat% of more than 17%. Body fat% was found to be directly proportional to the resting HR and inversely proportional to the physical fitness parameters of aerobic. Systolic BP was directly related toBody fat percentage and inversely related to Aerobic capacity.*

Keywords: Body composition, body fat percentage, aerobic capacity, blood pressure, young males

1. Introduction

Body composition refers to lean tissue mass and fat mass. Lean tissue mass is composed of muscles, bones and organ. Fat mass includes essential fat, storage fat and fat of no real purpose.[1]it depends on age, race, sex and location.[2] it is measured using skin fold thickness.[3]

Aerobic capacity refers to ability to sustain exercise tolerance. It is an important physical fitness factor. It is evaluated using VO2 max. And VO2 max is calculated using Harvard step test. It is a well-known fact that obesity i.e. increased body fat percentage is associated with hypertension and other metabolic diseases. We also know that athletes who have lower fat percentage and good exercise capacity have normal or lower blood pressure as compared to the other individuals.Variations in body mass may explain nearly 70% of the differences in VO2max scores among individuals.

Blood pressure depends on various factors like condition of blood vessel, aerobic capacity, body fat percentage, dietary factors etc. The association among aerobic capacity, body fat percentage and blood pressure has been studied in diseased individual. However it is not studied among healthy individuals.

The rationale behind selecting only healthy males in the selected age group was to avoid confounding factors like contribution of differing lifestyle patterns, dietary habits and underlying diseases of the cardiorespiratory system. The advantage of taking subjects entirely from the student group was to obtain maximum correlation in a select healthy group of 18-21 year old males that followed almost similar if not identical daily activities, diet and were all confirmed non-smokers and non-drinkers. This experimental design with the three variables of VO2max, resting BP/ HR and body fat % could accomplish the stated objective of understanding the extent of contribution of body composition on physical fitness in a select group.

The study was directed at elucidating effect of the body composition of untrained individuals on the aerobic capacities such that the inferences drawn from this study would form a strong physiological basis for application in selection and training of individuals in the age group 18-21 years for best results in sporting activities. Much stress is laid on being physically fit, with regular exercises and prevention of obesity. However there is a lack of population based studies in the country.

Hence this study was undertaken to analyze the body composition, the role of body fat percentage and aerobic capacity on resting BP / HR on in a selected group of healthy Indian males in the age group 18-21 years, using standardized methods of evaluation.

2. Review of Literature

Cardiovascular fitness reflects the maximal amount of oxygen consumed during each minute of near-maximal exercise. These values for maximal oxygen consumption or VO2max can range from 10ml/kg/min in cardiac patients to 80-90 mL/kg/min in world class runners and cross-countrymen. Runners and swimmers attain VO2max values nearly double that of sedentary persons. A muscle's predominant fiber type (type I & II) contributes to success in certain sports or physical activity. Humans possess two distinct types of muscle fibres, each with unique metabolic and contractile properties (1) low glycolytic- high oxidative, slow-twitch fibres (type I) and (2) low oxidative- high glycolytic fast twitch (type II) fibres. Intermediate fibres also exist with overlapping metabolic characteristics. A steady rate of oxygen consumption represents a balance between energy requirements of the active muscles and the aerobic synthesis of ATP. Maximum oxygen consumption (VO2max) quantitatively defines a person's maximum capacity to synthesize ATP aerobically. VO2max provides an important indicator of overall physiologic functional capacity and ability to sustain high intensity exercise. Oxygen consumption remains elevated above the resting level following exercise. Recovery oxygen consumption reflects the metabolic demands of exercise in addition to physiologic imbalances caused by exercise that last into recovery.

There are various studies carried out in western countries with respect to above mentioned factors. **Tomoko et al** in their study proved that aerobic exercise reduces the arterial stiffness in post-menopausal females and hence reduces the blood pressure[4]. **Mitchel et al** showed that the current BMI of children is associated with blood pressure[5]. **Wanzuhu et al** also proved that adiposity is associated with increased blood pressure[6]. Change in body composition is significantly linked to the systolic BP Change in response to exercise. This fact was verified by **Nobuyuki et al** in their study.

Above mentioned studies were carried out on western population and on either pediatric age group or older populations. Hence to bridge the gap in literature the present study was carried out.

3. Material and Methods

The present study was carried out over a period of 02 months from July 2010 to Aug 2010 at department of physiology of a medical college. Young healthy Indian adult male of age group 18-21 years were included in the study.

A total of 50 healthy male volunteers with no known prior health problem, addiction to alcohol or smoking or prior training were selected for the study.

Methodology

The height was measured using **Stadiometer (LECA WOGEL AND HALKE-HAMBURG).**Weight was measured using the same Stadiometer. It is based on the principle of balance. Weight was taken 3-4 hours after last meal.Resting Pulse was taken manually before step test and measurement of BP using a stopwatch.Pulse after step test was taken in the same way as the resting pulse. It was taken during the interval 1-1.5 minutes after completion of the step test while person was sitting after completing the Harvard Step test as per protocol. Blood Pressure was taken by sphygmomanometer in the right arm when the subject was sitting upright before doing the step test.

Harvard Step Testis a test of aerobic fitness.[7,8,9,10]
Equipment required were:
1) Step or platform 20"/50.8 cm high for males, in this study a wooden platform was used which was tested for its use and standardized.
2) Stopwatch for time duration of 5 minutes allotted for each subject and measurement of pulse rate during recovery,
3) Metronome to set the pace of exercise testing.

Procedure: Subject steps up and down on the platform at a rate of 30 per minute (every 2 seconds) for 5 minutes. Subject immediately sits down on completion of the test and heart rate is counted between 1 to 1.5 minutes after exercise. This is the short form of the test (Long form of the test requires an additional heart rate measurement between 2 to 2.5 minutes and 3 to 3.5 minutes.) This test can also be self-administered and requires minimal cost and equipment.
Validity: correlation to VO2max has been reported as between 0.6 to 0.8 in numerous studies[11].

Calculation of VO2max by Astrand Sheet

VO2max was calculated using Astrand Sheet by comparing pulse rate obtained after Step Test and body weight of the individual. In this sheet there are 3 scales on one of which pulse rate is marked, other one has body weight (in kg) and in the third one VO2max. The scale for VO2max is oblique and placed in the centre of other two. For calculating the VO2max, the pulse rate after Harvard Step Test and the weight of the individual were matched. The point at which the VO2max scale was intersected was noted and this was taken as the VO2max for the individual.

Measurement of Body Fat Percentage by measuring skinfold thickness:
This test estimates the percentage of body fat by measuring skinfold thickness at specific locations on the body.[12].
Skinfold measurement is taken at specific sites on the right side of the body. Special skinfold calipers (in this study: **SLIMGUIDE skinfold calipers, creative health products, Plymouth Mich)** were used to measure the skinfold thickness in millimeters. Two measurements are recorded in each site and averaged.

The measurement sites do vary depending upon the specific skinfold testing protocol being used, but typically, and in this study design, the following were the seven locations: Triceps, Pectoral, Subscapular,Midaxilla, Abdomen, Supra-iliac, Quadriceps.

Formula For Calculating Percent Body Fat from Skinfold Measurements
The most commonly used equations for body fat calculations based on skinfold measurement are based on Jackson-Pollock's equation for **bone density and Siri's formula** to get body fat percentage from that:

Steps (3) involved in the calculation of Body Fat Percentage[12] (Male):
Step 1: Seven Skinfold Sites (all 7 sites from above, SUM7 is the sum of all the measurements in mm)

Step 2: Bone Density = 1.112 - (0.00043499 * SUM7) + (0.00000055 * SUM7²) - (0.00028826 * Age)

Step 3: Body Fat Percentage = [(4.95/Bone Density) - 4.5] 100

Accuracy: According to the American College of Sports Medicine, when performed by a trained, skilled tester, skinfold measurements of body fat are up to 98% accurate.

Data Collection and Evaluation

The data was collected and tabulated in excel sheet and was analyzed using SPSS 15.0 and Epi Info software.

Observation and Results

The findings are illustrated objectively with the aid of the following tables and figures with relevant observations:

Table 1

Categories	Body fat %	VO2 max (L/min)	Resting HR (bpm)	Resting SBP (mmHg)	Resting DBP (mmHg)	Pulse pressure (mmHg)	MABP (mmHg)
I	< 13% (37)	3.7	75.32	118.6	74.5.	43.7	88.9
II	13-17% (09)	3.9	76	119.1	70.2	48	86.4
III	>17% (04)	3.3	76.75	122.5	71	51.5	88.2

Observation: The average VO2max was highest (3.9 L/min) in category II Body fat % (13-17%) and least (VO2 max 3.3 L/min) in category III Body fat % (>17%). Average Resting HR was the highest in Category III body fat%.

Table 2

Categories	VO2 max (L/min)	Body fat %	Resting HR (bpm)	Resting SBP (mmHg)	Resting DBP (mmHg)	MABP (mmHg)
I	>4 (17)	11.6	73.1	120.6	75.6	90
II	3-4 (24)	9.9	74.8	117.6	73.5	88.4
III	2-3 (9)	8	82.1	117.7	69.1	85.3

Observation: In this study comprising of 50 subjects in the age group of 18-21 years, 24 i.e., nearly 50% had VO2max between 3 L/min - 3.9 L/min and their average body fat% was 9.9%. 25% subjects who had VO2 max of >4 L/min had a higher average body fat% at 11.6% while lower VO2max (2 to 3 L/min) had body fat% that averaged at 8%. Lower resting HR (avg, 73.1 bpm) wasfound in Cat I VO2 max of >4 L/min when compared to higher resting HR (avg. 82.1 bpm) in Cat III VO2 max of values between 2L/min and 3L/min. Higher RHR (resting heart rate) corresponded to lower body fat% (average 82.1 bpm in Cat III VO2max and 8% body fat) while a lower RHR accompanied higher body fat % (average 73.1 bpm in Cat I VO2max and 11.6% body fat)

Table 3

Categories	Resting HR (bpm)	Resting SBP (mmHg)	Resting DBP (mmHg)	Resting PP (mmHg)	Resting MABP (mmHg)	Body fat %	VO2max (L/min)
I	60-69 (8)	115.8	75.3	40.5	88.8	10.4	3.7
II	70-79(29)	119.2	73.7	45.5	88.8	10.1	3.8
III	>80 (13)	119.2	71.3	47.1	87.1	11.4	3.3

Observation: When the average RHR was high, Cat III RHR i.e., >80 bpm (in 13 subjects), the average VO2max was lower (3.3 L/min) in comparison to the VO2 max findings of 3.7 and 3.8 L/min in lower RHR (Cat I,60-69 bpm and Cat II, 70-79 bpm). It is interesting to note that body fat % was high in Cat III RHR which also had the lowest VO2 max whereas body fat % was found to be much lower in when VO2 max was on the higher scale of 3.7 and 3.8 L/min in 37 out of 50 subjects included in this study. Only 13 subjects had high RHR (>80bpm), high body fat% (11.4%) and relatively low VO2max (3.3 L/min).

Table 4:

Categories	Resting SBP (mmHg)	Resting DBP (mmHg)	Resting PP (mmHg)	Resting MABP (mmHg)	Body fat %	VO2max (L/min)	Resting HR (bpm)
I	110-130 (40)	72.8	46.9	88.5	10.9	3.7	76.7
II	<110 (6)	72.7	32	83.8	9.5	3.5	72.7
III	>130 (4)	81	50.5	95.3	13.6	4.6	74.3

Observation: In this study, 40 out of 50 subjects, i.e., 80% of the subjects had SBP in the range 110-130 mmHg (body fat % : 10.9%) while 6 subjects had SBP< 110mmHg (MABP: 83.8 mmHg) and an average body fat% which was lower (9.5%) and 4 subjects had a SBP of >130 mmHg (MABP: 95.3 mmHg) and higher body fat% (13.6%).

Table 5

Categories	Resting DBP (mmHg)	Resting SBP (mmHg)	Resting PP (mmHg)	Resting MABP (mmHg)	Body fat %	VO2max (L/min)	Resting HR (bpm)
I	70-90 (28)	120.4	43.4	91.7	10.4	3.6	76.4
II	< 70 (20)	115.9	49.8	82.2	10.7	3.8	75.5
III	>90 (2)	122	26	104.6	8.3	3.7	69

Table 6:

Categories	Resting MABP (mmHg)	Resting SBP (mmHg)	Resting DBP (mmHg)	Resting PP (mmHg)	Body fat %	VO2max (L/min)	Resting HR (bpm)
I	90-100 (22)	122.6	89	45.2	8.33	3.8	76.2
II	< 90 (26)	115.6	79.5	49.4	10.4	3.7	75.6
III	>100 (2)	129	96	26	9.93	3.7	75.6

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Table 7:

	maximum	minimum	average
Body fat %	19.67 %	4.57 %	10.47 %
Vo2max	5.4 L/min	2.0 L/min	3.7 L/min
Resting HR	98bpm	60bpm	75.56bpm
SBP	136 mmHg	98 mmHg	118.7 mmHg
DBP	98 mmHg	50 mmHg	73.4 mmHg
Pulse pressure	72 mmHg	18 mmHg	45.2 mmHg

It was observed that BMI (wt in kg /ht^2 in meters) was a maximum of 28.06 kg/m^2 and a minimum of 16.08 kg/ m^2 with an average BMI (in 50 healthy male subjects) 21.69 kg/m^2

4. Discussion

When an exercise is performed, the initial rapid increase in heart rate suggests a central command, or a rapid reflex from mechanoreceptors in the active muscles. Later, increases in heart rate stem from reflex activation of the pulmonary stretch receptors and reflexes from exercising muscles and are due to increases in sympathetic tone and vagal withdrawal as well as increases in circulating catecholamines[13]. In this setting, the associated marked acceleration of heart rate is the predominant factor increasing the cardiac output. The positive inotropic stimulation also shortens ejection and increases the rate of relaxation which together with increased atrial contraction due to augmented atrial contractility enhances ventricular filling.

Physical conditioning or training affects the cardiopulmonary and skeletal muscular systems in a variety of ways which improve work performance [14]. This adaptation favors aerobic metabolism and endurance [15]. Endurance athletes have lower resting and exercise heart rates, which may in part relate to “down regulation” of cardiac beta-adrenergic receptors secondary to repeated and prolonged episodes of sympathetic stimulation during exercise. [16]

The region in which oxygen consumption plateaus or increases only slightly with additional increases in exercise intensity represents the maximal oxygen uptake, maximal aerobic power, aerobic capacity or, simply VO2max. The VO2 max provides a quantitative measure of a person’s capacity for aerobic ATP synthesis. This makes VO2max an important determinant of the ability to sustain high-intensity exercise for longer than 4-5 minutes. [17] Attaining a high VO2max require integration of high levels of pulmonary, cardiovascular and neuromuscular function. This makes VO2 max a fundamental measure of physiologic functional capacity for exercise.

Bench-stepping (Step test) has produced VO2max scores identical to treadmill values and significantly higher than values on a cycle ergometer. [18] Variations in body mass may explain nearly 70% of the differences in VO2max scores among individuals.[19] this limits interpretations of exercise performance or absolute values for oxygen consumption when comparing individuals who differ in body size or composition.

Since gender differences in VO2 max and body composition in males and females are biologically inherent and unalterable, only males were included in this study. Age does not spare its effect on VO_2max, therefore, young adult males in the age group 18-21 were selected so that the data provides an insight into the variables under study. VO_2 max declines steadily after age 25 years at a rate of 1% per year so that at age 55 years it averages about 27% below values reported for 20 year olds.

In this study comprising of 50 healthy Indian males in the age group of 18-21 yrs with an average BMI of 21.69 kg/m^2, all medical students studying in AFMC, Pune, was found that the average body fat % was 10.47% with a maximum of 19.67% and a minimum of 4.57%. The body fat % was derived using skin fold thickness measurement The VO2 max in the group of 50 subjects was an average of 3.7 L/min with a minimum of 2 L/min and a maximum of 5.4 L/min. The resting HR was an average of 75.56 bpm while the range of RHR was between 60 to 98 bpm. In this study the systolic BP, diastolic BP and pulse pressure were found to be 118.7 mmHg (98-136 mmHg), 73.4 mmHg (50-98 mmHg) and 45.2 (18-72 mmHg) respectively.

The increase in aerobic capacity in the group having body fat % 13-17% as compared to the group having body fat % of < 13% is an important finding in this study and needs more research in this direction for conclusive results regarding importance of body fat in exercise metabolism.

5. Conclusion

It can be concluded VO2 max, aerobic capacity or physical fitness is better in the group which has optimum body fat percentage and it is less when body fat % is greater than

17%. It can also be concluded that the resting heart rate is lower in the group of subjects that have lesser body fat% and is found to be highest when body fat % was more than 17%. There were no relevant findings regarding blood pressure (systolic, diastolic, pulse pressure and mean) correlating with heart rate, body fat% and physical capacity in this group of 50 healthy Indian males in the age group 18-21 years.

The VO2max was found to be highest in that category of Body fat % which ranged from 13% to 17% and was least in the category of Body fat % greater than 17%. Average Resting HR was the highest in the group of subjects that had higher body fat% of more than 17%. Body fat% was found to be directly proportional to the resting HR and inversely proportional to the physical fitness parameters of aerobic capacity or VO2 max in this study comprising of 50 healthy Indian males in the age group 18-21 years.

6. Limitations of this Study

Biomechanical characteristics vary between individuals. For example, considering that the step height is standard taller people are at advantage as it takes less energy to step up onto the step. Body weight has also been shown to be a factor.

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