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Exercise Capability with Total Body Fat Percent & Skeletal Muscle Percent in Male Students aged 18 - 25 Years: A Correlational Study

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ABSTRACT

***Introduction*:** Obesity is considered the greatest health problem in the modern industrial world; the 5th leading risk factors; cause of death in 2004, according to World Health Organization (WHO). It is a medical condition where excess body fat, accumulated in body, exerts adverse effects on health, thus a negative factor for health and longevity in society.
***Objectives*:** To assess aerobic exercise performance; overweight and/or obesity, if any among the studied population and also to assess correlation between exercise capability with total body fat % and skeletal muscle % of the participants.
***Methods*:** 118 male medical students (18- 25 years of age) were selected for the present study, based on the Inclusion and Exclusion criteria. In this study conducted for 1 year (12 months), Questionnaire method was followed, along with Stadiometer (for height), Weighing machine (for body weight), Mercury Sphygmomanometer and Stethoscope (for blood pressure), Karada scan machine (for total body fat and skeletal muscle %), Treadmill Test machine (for exercise capability including VO_2 max and MET), ECG machine (for cardiac health assessment), Anthropometric measurements (for BMI, waist - hip ratio) etc were used. Data obtained were Statistically analyzed to check the level of significance.
***Results*:** Both VO_2 max and MET exhibited significant negative correlation with body fat % and BMI, while a significant positive correlation was present with Skeletal muscle %. Similarly, endurance time or TMT showed a significant positive correlation with Skeletal muscle % and a significant negative correlation with both Body fat % and BMI. Significant positive correlation between MET and Skeletal muscle % were observed. Mean value of Body fat % and BMI were higher (statistically significant) in Overweight/Obese subgroup, while Skeletal muscle %, VO_2 max, TMT and MET were more in normal BMI subgroup.
Conclusion: The present study concludes that, decreased physical fitness along with excess body fat, leads to a decline in aerobic exercise capability. Low cardio-respiratory fitness in young adults with increased body fat could be a factor for developing cardiovascular co-morbidities later in middle age. Hence, this study is relevant in current scenario.

INTRODUCTION

Obesity is considered the greatest health problem in the modern industrial world; the 5th leading risk factors; cause of death in 2004, according to World Health Organization (WHO) (1,2). India is no lagging behind, with 5% of the country's population is affected with morbid obesity (3).
Obesity is referred as a medical condition where excess body fat, accumulated in body, exerts adverse effects on health, thus a negative factor for health and longevity in society. Based on fat distribution, obesity is classified as: Central / apple-shaped / android obesity (fat accumulation in abdominal region mainly) and peripheral / pear-shaped / gynoid obesity (fat accumulation in limbs including hips, thighs, legs mainly). A central distribution of body fat is associated with a higher risk of morbidity and mortality than a more peripheral distribution (4).
Physical inactivity is a major factor for increase in obesity and its complications (5). Physical fitness is a general state of health and well-being that provides the basis for sport performance (performance related to physical fitness) (10). Cardiovascular fitness profile (aerobic fitness capacity or body's ability to transport and use oxygen during prolonged, strenuous exercise or work) is one of the most important determinants to assess a person's physical fitness. Aerobic fitness is commonly measured by a person's maximum aerobic power (VO_2 max) - the maximum amount of oxygen that can be transported and used by working muscles i.e. oxygen utilization during maximal aerobic metabolism (11).
The direct assessment of VO_2 max in a laboratory setting is generally conducted with the use of commercially available

metabolic charts and requires highly trained staffs. Due to this complexity & high cost of direct assessment of VO_2 max, many professionals prefer to estimate it indirectly. Most of the hospital based practitioners usually choose the treadmill test using Bruce protocol, because it is a widely accepted and standardized method to evaluate the cardiovascular fitness (Annexure II). Bruce protocol is an indirect method of measuring VO_2 max which can also be expressed in terms of Metabolic Equivalent of Task (MET) or simply Metabolic Equivalent. Performance on the Bruce protocol is assessed by exercise duration, from which we can calculate the VO_2 max and Metabolic Equivalent with the help of standardized formulae. MET is the resting metabolic rate or the amount of energy expended while an individual is at rest; one MET is equivalent to one times the resting metabolic rate (12).

Since Bruce protocol is a maximal test, only very fit athletes can complete all the stages in it, and most subjects get fatigued and discontinue before the end of the test. So a functional end point is set there to denote an acceptable level of cardiovascular fitness. This end point is clinically taken to be the achievement of the target heart rate (THR). Target heart rate is 85% of the maximal predicted heart rate of the subject, which is set by the most accepted formula for both sexes: [220 – Age (in years)] (13).

In assessing cardiovascular fitness by Bruce protocol, the most important parameter is the duration, for which the subject can continue on the treadmill. Longer time duration on treadmill to achieve the target heart rate indicates a more gradual rate of heart rate rising during the exercise test. This signifies better cardiovascular conditioning and fitness, as the cardiovascular system can accommodate the increasing demands placed on it through increasing intensity of exercise for a longer duration.

Physical fitness level also depends on body composition of the subject. Body composition reveals the relative proportions of fat and lean body mass of an individual. A number of methods are available for determination of different body compositions. Among them, Anthropometric measurements and Bioelectrical Impedance Analysis (BIA) method are most commonly used in clinical settings. (12, 13)

Bioelectrical Impedance Analysis (BIA) method is generally used for the determination of body fat and skeletal muscle %s. BIA is relatively simple, quick and non-invasive procedure which gives reliable measurements of body composition with minimal intra - and inter - observer variability (14). The results are available immediately and reproducible with < 1% error on repeated measurements (15).

Anthropometric measurements include several indices like Body Mass Index, Absolute Waist Circumference, Waist - Hip Ratio, Skin - fold thickness etc. BMI is the most widely used and standard index used by WHO for recording obesity statistics since early 1980s (16). WHO has categorized subjects into lean, overweight and obese, based on BMI (Annexure III) (17). But due to variations in body proportions, standard BMI classification may not reflect the actual body fat in different populations. In Asian subjects, the risk association with cardiovascular diseases occurs at relatively lower levels of BMI compared to the European population. This is attributed mainly to body fat distributions; Asian Indians tend to have more visceral adipose tissue, despite having lean BMI (17).

In fact, the BMI guidelines for the Indian population have been revised recently. The guidelines were released jointly by the Health Ministry, the Diabetes Foundation of India, the All India Institute of Medical Science (AIIMS), Indian Council of Medical Research, the National Institute of Nutrition and 20 other health organizations (Annexure III) (17).

In recent decades, decline in physical activity particularly among young adults has been observed. This reduction in the physical activity affects body composition factors like body fat %, skeletal muscle %, body mass index, waist - hip ratio etc. Previously many studies were done based on association between exercise and BMI or waist - hip ratio. But limited studies were conducted on exercise and body fat or skeletal muscle %, particularly in young age population.

Keeping these factors in mind and acknowledging the growing epidemic of obesity in young adults of our country and its impact on cardiovascular health, the present study has been undertaken to assess any correlation between exercise capability with total body fat % and skeletal muscle % in male students aged from 18 to 25 years.

Low cardio-respiratory fitness in young adults with increased body fat could be a factor for developing cardiovascular co-morbidities later in middle age. Hence, health promotion polices and physical activity programs should be designed within the society to improve the general health and cardiovascular fitness levels. Schools and colleges should play an important role by identifying children and young adults with low physical fitness & by promoting positive health behaviors such as encouraging them to be active, with special emphasis on the intensity of the activity.

OBJECTIVES

i. To assess the aerobic exercise performance of the participating subjects using Bruce treadmill test protocol as a standardized exercise test.
ii. To assess overweight and/or obesity, if any, among the participating subjects by estimating body fat %s.
iii. To assess correlation between exercise capability with total body fat % and skeletal muscle % of the participants.

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MATERIALS & METHODS

Materials and methods used in the study were as follows:
Study Area - Department of Physiology, North Bengal Medical College & Hospital, Sushrutanagar, Darjeeling district, 734 012, West Bengal, India
Study Duration – 1 year (12 months)
Study Design - observational and cross sectional study
Study Population – 118 male medical students (18- 25 years of age) of North Bengal Medical College & Hospital, Sushrutanagar, Darjeeling district, 734 012, West Bengal, India
Inclusion Criteria - only Male subjects of 18 – 25 years' age group, healthy and willing were selected. Nature of the study and procedure to be undertaken were fully explained to all the subjects. A detailed history of the subjects was taken including their present & past medical history, family history, addiction history etc. A written consent was also taken from each of the subjects prior to the study procedure.
Exclusion Criteria (18,19):

I. Unwilling to give informed consent
II. Past or present history of following medical conditions:
III. Coronary heart disease
IV. Cyanotic heart disease
V. Asthma
VI. Exercise induced bronchospasm
VII. Acute infective disease
VIII. Vertigo or other vestibular pathology
IX. Low back pain
X. Physical deformity
XI. Recent surgery or any fracture (within last 4 months)
XII. Metabolic disorders (eg., diabetes, thyroid function abnormalities etc)
XIII. History of taking long term medications like:
XIV. Calcium channel blockers
XV. Anti-arrhythmic drugs
XVI. Beta blockers
XVII. Anti - anginal drugs
XVIII. Digitalis
XIX. Anti-convulsants
XX. Anti-hypertensive
XXI. CNS stimulants
XXII. Diet medications (appetite suppressants/anti-obesity drugs)

The following findings on medical screening:

a. Abnormal resting ECG showing dysrhythmias, conduction disturbances and evidence of ischemia
b. Resting pulse rate > 100 beats per minute
c. Systolic blood pressure (SBP) > 180 mm Hg
d. Diastolic blood pressure (DBP) > 100 mm Hg
e. Irregular beats > 3 per minute
f. Subjects having any kind of metallic or electronic prosthesis

Study Tools -

1. Consent form
2. Questionnaire format
3. Stadiometer (Avery India Ltd)
4. Karada scan machine (Omron 375 - HBF)
5. Mercury sphygmomanometer and Stethoscope
6. Treadmill Test machine (Schiller Health Care India Pvt Ltd)
7. ECG machine

Study Technique -
Collection of data **-** every volunteer was explained about the purpose & procedure of the study.
After getting verbal consent, they were given the printed consent form to sign. They were made familiar with the equipment and instructed to discontinue the test if they faced any discomfort, and report immediately.

1. Questionnaire - subjects were asked about the following details from the questionnaire format:
Name and age
Any history of present illness or past illness
Any drug history or surgical history
Family history of any diseases

A systematic general survey was conducted afterwards to get information about height, weight; pallor /cyanosis/clubbing /edema/jaundice (clinically), if any.

2. **Stadiometer** - Height was measured in standing position using Standard Stadiometer (supplied by Avery India Ltd) to the nearest centimeter (cm). During height measurement subject was asked to stand erect with knees together and shoulders relaxed, looking straight ahead, while the occiput, back, buttock and bare heel were touching the stadiometer. The heels were placed together with the feet pointing slightly outwards at a 60^o angle and the arms hung freely by the sides of the trunk with palms facing the thighs (19).

3. ECG - electrodes (supplied by Medico Electrodes International, USA) were placed on the skin after adequate skin preparations according to the Mason-Likar modification of the standard 12 lead ECG. Chest electrodes (V1-V6) were placed according to the standard ECG protocol (19).
Lead placements:
RA – below the distal end of the right clavicle, on the superior aspect of the pectoralis major LA – below the distal end of the left clavicle, on the superior aspect of the pectoralis major
RL – right anterolateral aspect of the abdomen at the level of the umbilicus
LL – left anterolateral aspect of the abdomen at the level of the umbilicus

4. Treadmill Test - Exercise capability was assessed by using a Whisper mill 594XL treadmill machine running on SPANDAN software, version 4.0 (both supplied by Schiller Health Care India Pvt Ltd). The treadmill was programmed to increase in gradient and speed in every 3 min, in seven stages, according to Bruce Protocol (Annexure II) (20). The tests were conducted in an air - conditioned room maintaining a constant temperature and a constant relative humidity. The subjects were asked to wear comfortable shoes and to restrict their food intake at least 1.5 hours before the test. Blood pressure (BP) of each subject was measured and recorded just prior to the test, after the completion of each stage and immediately after the test using a manual mercury sphygmomanometer. The pulse rate and ECG were monitored continuously before, during and up to until 5 min from the cessation of the test.
During the test, the subject was continuously monitored for the manifestation of any warning signs and continuous verbal feedback was gathered from the subject to ensure safety and avoid adverse outcome. The treadmill test was continued till the subject achieved the target heart rate or the treadmill test was prematurely terminated due to the causes outline below-
Criteria for *premature termination* of the test (19, 21, 22):
Subject requests to stop due to fatigue and/or exhaustion. Appearance of the following signs/symptoms-

- Pain in the chest, neck, shoulder, pain radiating down one or both arms etc
- Moderate/severe leg pain or cramping
- Light-headedness, dizziness
- Severe shortness of breath/wheezing
- Change in skin color to bluish/grayish
- Severe headache
- Subject appears confused or agitated
- Nausea
- Unstable gait
- Visual problems

Appearance of following *cardiovascular abnormalities* -

a. Systolic blood pressure ≥ 260 mm Hg and/or diastolic blood pressure ≥ 115 mm Hg during exercise
b. Significant drop (≥20 mm Hg) in systolic blood pressure during exercise
c. Failure of systolic blood pressure to rise with increasing exercise intensity (≥10 mm Hg above baseline)
d. Failure of the heart rate to increase by 5 beats per minute during a given workload compared to the previous workload
e. Repeated noticed variability during a stage (like sudden changes of ± 30 beats/minute) after checking electrode connections

Appearance of the following *ECG abnormalities* –

a. ST or QRS changes such as excessive ST depression (>2 mm of horizontal or down sloping ST-segment depression) or marked axis shift.
b. ST segment elevation > 1 mm in non-Q wave lead

c. Frequent ventricular extra-systoles
d. Onset of ventricular tachycardia
e. Atrial fibrillation or supra-ventricular tachycardia
f. Development of new bundle branch block
g. Second or third degree heart block
h. Cardiac arrest

The end point of a successful treadmill test was clinically taken when the target heart rate was achieved which was specific for a particular subject. The target heart rate was taken to be 85% of the maximal predicted heart rate of the subject, which was set by the formula: [220 – Age (in years)] (13). In this study, all the subjects attained their respective target heart rates, as expected in this age group. The total exercise duration in minutes was noted. The post exercise recovery period was continued till the pulse rate and blood pressure returned to baseline, with the subject in seating position on a stool. The exercise testing session ended after verifying the data obtained and ensuring the complete recovery of the subject. All the testing procedures were conducted under proper medical supervision.

5. Karada Scan Machine - total body fat and skeletal muscle % were measured by using Karada Scan machine (HBF 375, supplied by Omron Company). The whole procedure to be undertaken was explained to the subjects primarily.
After turning on the power of the machine, personal data such as age, sex, height of the subject were feed by digital settings. As it was a step-on machine, the weight of the subject was measured during the procedure. Now the subject was asked to step on the foot-electrode plates of the machine with bare feet and to hold the grip- electrodes of the scanning device with both hands keeping them straight with extended elbows, maintaining a 90º angle between body and arms. It took about 30 - 40 seconds to scan the whole body and results were displayed in the digital display board of the machine. The machine works on the principles of Bioelectrical Impedance Analysis (BIA): two or more conductors are attached to a person's body and a small & weak electric current is sent through the body. The resistance between the conductors will provide a measure of body fat, since the resistance to electricity varies between adipose and muscular tissue. Fat - free mass (muscle) is a good conductor as it contains large amount of water (about 73%) and electrolytes, while fat is anhydrous and a poor conductor of electric current (23).

- Criteria to be maintained during the procedure:
  - Input of personal data (age, sex, height) properly
  - Standing on the foot electrodes in bare feet
  - Maintaining 90º angle between body and arms while holding the grip electrodes
- Precautions to be taken (24, 25):
  - Avoiding any type of gadgets like mobiles, watches or metallic items like coins, keys, rings etc, on the subject, during the procedure
  - Excluding subjects having any kind of metallic plate implants or electronic implants like pacemakers
  - Not taking measurements soon after drinking, eating, exercising or when dehydrated

Study Variables

1. **Body fat %**
2. **Skeletal muscle %**
3. **Body Mass Index (BMI)** - BMI was calculated according to the formula (26):
BMI = weight (kg) / [height (m)]^2
4. **Aerobic capacity**- aerobic exercise capacity of the subject was judged from VO_2 max and also expressed in terms of METs (27).
5. **VO_2 Max** - it is the oxygen utilization of the entire body during maximal aerobic metabolism. It is expressed in the unit of ml/kg/min’. In this study it has been calculated from the total exercise duration according to the following formula:
VO2 Max = 14.8 - (1.379 x T) + (0.451 x T2) – (0.012 x T3).
[T – Total exercise time in minute]
6. **Metabolic Equivalent of Task or Metabolic Equivalent (MET)** - it is the amount of energy expended while an individual is at rest; 1 MET is equivalent to 1 times the resting metabolic rate. MET has been derived from the VO_2 max according to the following relations:
1 MET - 3.5 ml O_2 /kg/min. Total MET = VO_2 max /3.5

7. Data Analysis - collected data, according to the study variables, were entered into the Microsoft Office Excel spreadsheet (v.2007) and subsequently analyzed using the statistical analysis software SPSS (v.16). The frequency distribution of the data in the different sets was determined for the entire study population. Bivariate analysis was used to determine the co-relation co-efficient between the different data sets. Pearson correlation was done, where $r < 0.5$ was regarded as weak and $r > 0.5$ was regarded as strong correlation; (+ve) and (-ve) signs indicated the direction of correlation. Linear regression was used to measure trends between VO_2 max, MET, body fat and skeletal muscle %.
Subsequently, the anthropometric data of the subjects were divided into 2 sub-groups (Normal and overweight/obese) based on the current Indian cut-offs for BMI. Independent t - test was then used to compare the data according to the study

variables between these 2 sub-groups.

RESULTS

Out of 118 participants, 62 were normal and 56 were overweight/obese, according to the current BMI guidelines. Units: VO_2 max - (ml/kg/min); 1 MET - (3.5 ml O_2/kg/min); BMI - kg/m^2; TMT - minute; Body fat - %; Skeletal muscle - %
TABLE 1: Correlation between different study variables. (n = 118)

Parameters	VO_2 max	MET	TMT
Body Fat (%) - Correlation (r)	-0.686**	-0.686**	-0.683**
-Sig. (2 - tailed)	0.000	0.000	0.000
Skeletal muscle % - Correlation (r)	0.706**	0.706**	0.703**
-Sig. (2 - tailed)	0.000	0.000	0.000
BMI - Correlation (r)	0.813**	0.813**	0.825**
-Sig. (2 - tailed)	0.000	0.000	0.000

** Correlation (Pearson) is significant at the 0.01 level (2 - tailed)

Both VO_2 max and MET exhibited significant negative correlation with body fat % and BMI, while a significant positive correlation is present with Skeletal muscle %. Similarly, endurance time or TMT shows a significant positive correlation with Skeletal muscle % and a significant negative correlation with both Body fat % and BMI.

Table 2: Profile of different study variables among the study population (n = 118)

Parameters	Mean	Range	Standard Deviation	Standard Error of Mean
Skeletal muscle %	33.25	29.40 - 38.40	2.24	0.21
Body fat %	21.12	12.20 - 29.60	4.28	0.39
TMT	7.75	3.80 - 11.40	1.83	0.17
VO_2 max	26.18	15.41 - 37.91	5.97	0.55
MET	7.48	4.40 - 10.83	1.70	0.16
Body mass index	22.98	17.05 - 31.37	3.18	0.29

Mean value of Body fat % and Skeletal muscle % were 21.12% and 33.25% respectively. Mean VO_2 max achieved was 26.18 ml/kg/min and mean BMI was 22.98 kg/m2. Mean exercise duration was 7.75 min.
Table 3 and Table 4 represent profile of different study variables among Normal BMI subgroup (n = 62) and Obese subgroup (n = 56) respectively.

Table 5. Mean value of Body fat % and BMI were higher in Obese subgroup (Group 2), while Skeletal muscle %, VO_2 max, TMT and MET were more in normal BMI subgroup. The changes were significantly different in case of all the parameters.

TABLE 3: Profile of study variables among normal BMI subgroup (n= 62)

Parameters	Mean	Range	Standard Deviation	Standard Error of Mean
Skeletal muscle %	34.74	31.20 –38.40	1.74	0.22
Body fat %	18.23	12.20 – 24.40	3.43	0.43
TMT	9.21	6.60 – 11.40	0.78	0.10
VO_2 max	31.03	21.89 – 37.91	2.93	0.37
MET	8.86	6.26 – 10.83	0.84	0.11

TABLE 4: Profile of study variables among overweight/obese sub-groups (n = 56)

Parameters	Mean	Range	Standard Deviation	Standard Error of Mean
Skeletal muscle %	31.61	29.40 – 35.80	1.47	0.19
Body fat %	24.33	14.00 – 29.60	2.48	0.33
TMT	6.12	3.80 – 8.40	1.14	0.15
VO_2 max	20.81	15.41 – 27.93	3.20	0.42

MET	5.94	4.40 – 7.98	0.91	0.12

TABLE 5: Comparison of the study variables among the sub-groups

Parameters	Group*	Mean	Standard deviation	Standard Error of Mean	Significance test	
Skeletal muscle %	1	34.74	1.74	0.22	t: -10.447 df : 116 CI: 3.116±0.295	0.000 (p <0.05)
	2	31.61	1.47	0.19		
Body fat %	1	18.23	3.43	0.43	t: 10.935 df : 116 CI: 6.091±0.557	0.000 (p <0.05)
	2	24.33	2.48	0.33		
TMT	1	9.21	0.78	0.10	t: -17.247 df : 116 CI: 3.089±0.179	0.000 (p <0.05)
	2	6.12	1.14	0.15		
VO2 max	1	31.03	2.93	0.37	t: -18.116 df : 116 CI: 10.23±0.564	0.000 (p <0.05)
	2	20.81	3.20	0.42		
MET	1	8.86	0.84	0.11	t: -18.116 df : 116 CI: 2.923±0.161	0.000 (p <0.05)
	2	5.94	0.91	0.12		
Body Mass Index	1	20.50	1.60	0.20	t: 15.664 df : 116 CI: 5.232±0.33	0.000 (p <0.05)
	2	25.73	2.02	0.26		

*Group 1 – BMI: < 23 kg/m2 (n = 62); Group 2 – BMI: ≥ 23 kg/m2 (n = 56)

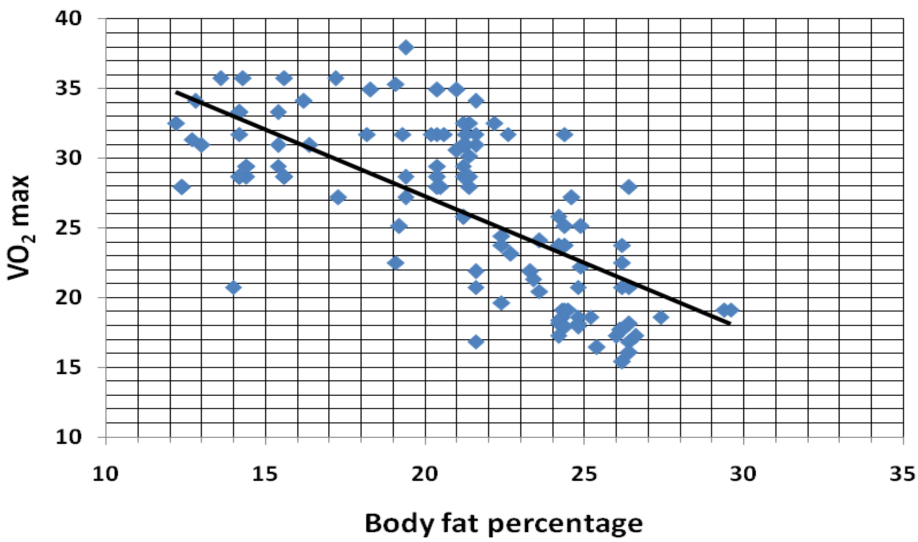

Figure1: Correlation between VO_2 max and body fat %

The above figure shows a significant negative correlation [r = - 0.686, p < 0.05 (0.000); Table 1] between VO_2 max and body fat %. Thus, with increase of body fat % the value of VO_2 max decreases.

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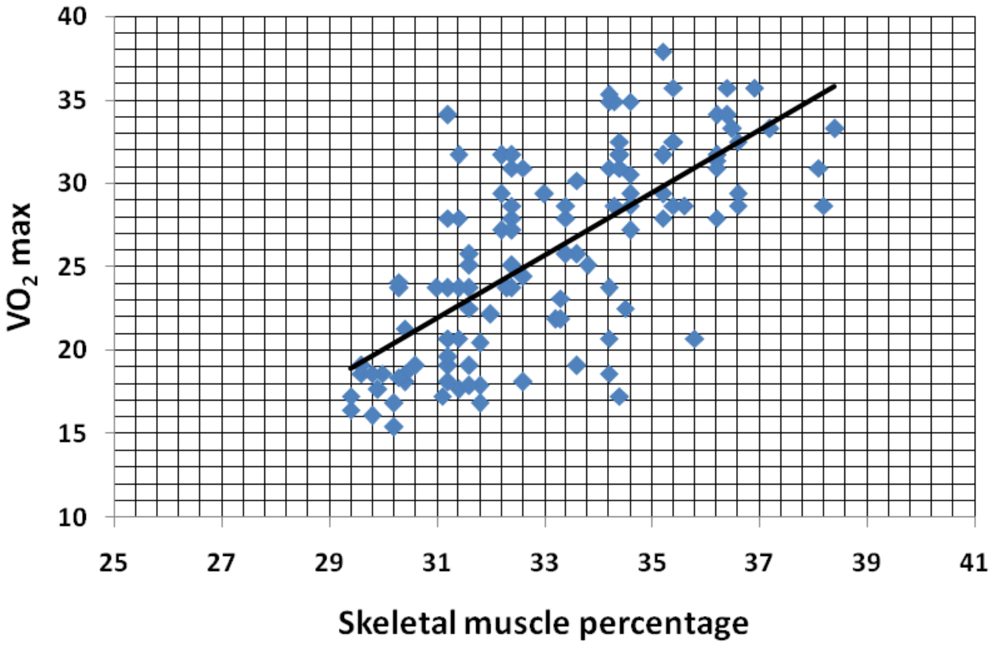

Figure 2: Correlation between VO_2 max and Skeletal muscle %

The above figure shows a significant positive correlation [r = 0.706, $p < 0.05$ (0.000); Table 1] between VO_2 max and Skeletal muscle %.

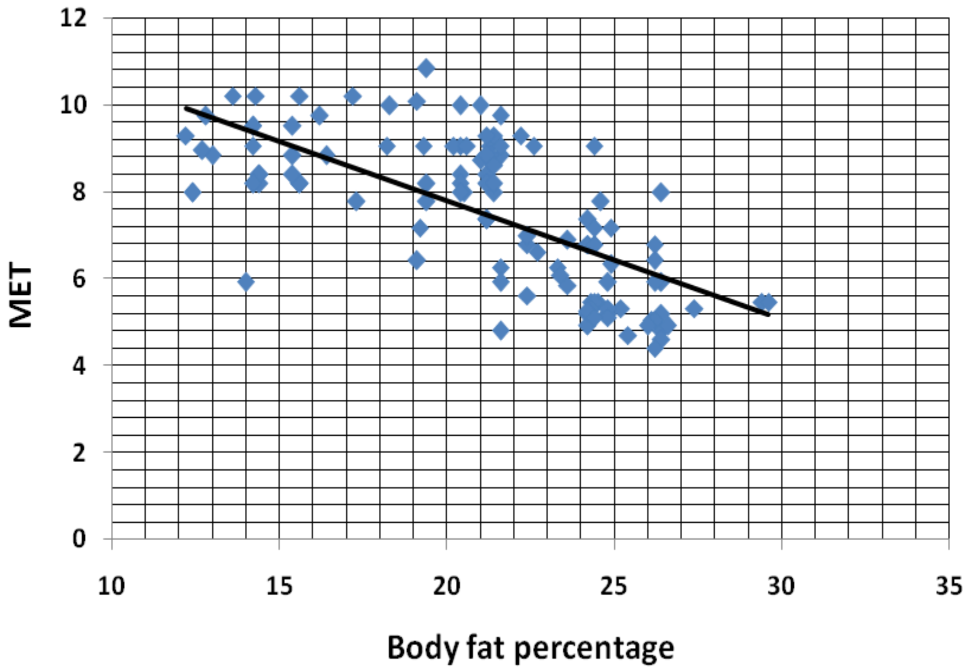

Figure 3: Correlation between MET and body fat %

The above figure shows a significant negative correlation [r = - 0.686, $p < 0.05$ (0.000); Table 1] between Metabolic equivalent (MET) and body fat %.

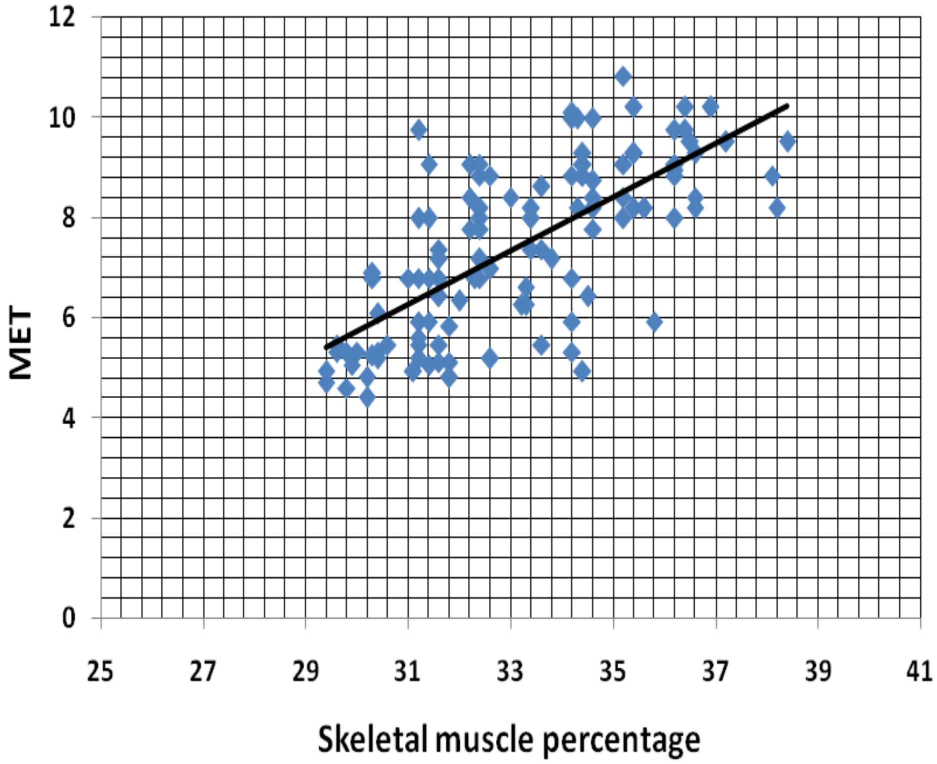

Figure 4: Correlation between MET and Skeletal muscle %

The above figure shows a significant positive correlation [r = 0.706, $p < 0.05$ (0.000); Table 1] between MET and Skeletal muscle %.

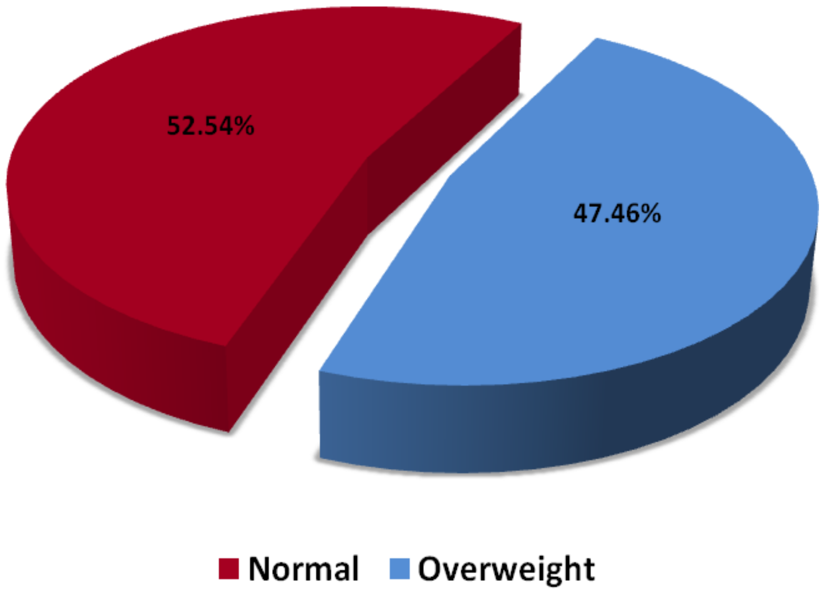

Figure 5: Distribution of the study population (n = 118) according to BMI.

The above figure shows that, among the total 118 participants, 52.54% (62 subjects) is under normal subgroup with BMI <23 kg/m^2 and remaining 47.46% (56 subjects) is under overweight subgroup with BMI ≥23 kg/m^2, based on current BMI cut-offs according to the Indian Obesity Guidelines.

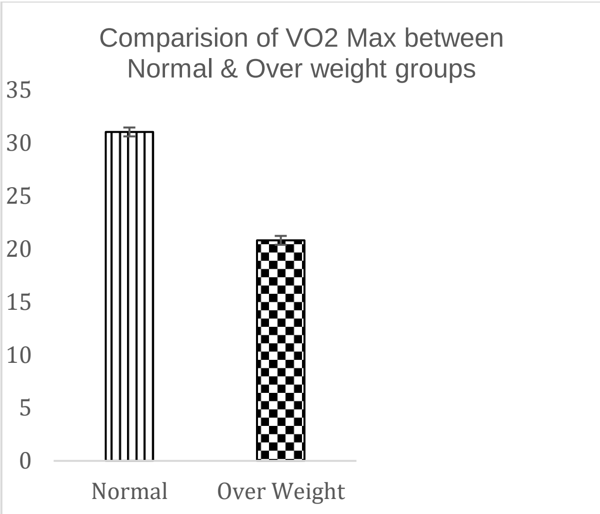

Figure 6: Comparison of Mean VO_2 max among the subgroups

The above figure shows that the mean value of VO_2 max is higher in normal subgroup (31.04 ml/kg/min) compared to the overweight subgroup (20.81ml/kg/min).

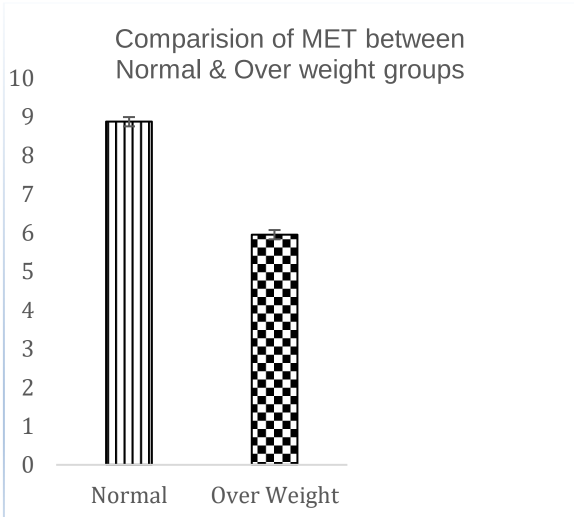

Figure 7: Comparison of Mean MET among the subgroups

The above figure shows that the mean value of MET is higher in normal subgroup compared to the overweight subgroup.

DISCUSSION

Incidence of cardiovascular risk factors is showing an alarming rise in both developed and developing countries and is encompassing all age groups from children to geriatric, owing to lifestyle, obesity, decreased physical fitness and cardiovascular risk factors etc. Effects of these risk factors are reflected through poor cardiovascular conditioning or capacity and can be evidenced from a decline in aerobic exercise capability. VO_2 max is considered to be the best indicator of aerobic fitness. Bruce treadmill test protocol is one of the most standardized methods of estimating VO_2 max. It is an indirect method of measuring VO_2 max which can also be expressed in terms of Metabolic Equivalents (METs). Performance on the Bruce protocol is assessed by exercise duration, from which VO_2 max and Metabolic Equivalent are calculated through standardized formulae.

The present study was designed to be an observational and cross-sectional study. An attempt was made to assess the correlations between exercise capability parameters with body fat and skeletal muscle %s. Subjects were divided into 2 sub-groups, based on the current cut-offs for BMI according to the Indian Obesity guidelines and comparison of the exercise capability parameters between these 2 groups were made.

In this present study, mean values of body fat % and BMI were lower in normal, compared to overweight group; while

the mean values of Skeletal muscle %, total exercise duration, VO_2 max and MET were higher in normal group compared to the overweight group; the mean differences are significantly different in case of all parameters.
The obtained data clearly points to a decline of aerobic exercise capacity with increasing adiposity and decreasing muscle mass, as reflected through the Pearson analysis. Similar results were also obtained from the study in relation to Body Mass Index (BMI); the exercise capability parameters were lower in overweight/obese group compared to the normal group. Thus the study has validated the well-established fact that excess adiposity in an individual act as a metabolic burden and leads to a decline in aerobic exercise capability and hence cardiovascular capacity as compared to lean subjects.
Sum of skin-fold thickness (indicating obesity) was negatively associated with exercise time and METs obtained from a study on healthy Chinese children of 8 - 13 years of age children by Sung *et al* (1999) (28). Strong negative correlation between BMI and endurance time was reported in the study by Chatrath *et al* (2002) on children between 4 - 18 years of age (29). Similar negative correlations were also obtained from the present study between endurance time (TMT) and body fat %.
Hulens *et al* performed 2 studies in 2001 and 2003 respectively, to assess the differences in exercise capacity parameters between lean and obese women, based on BMI. Similar parameters like VO_2 max and Rate of perceived exertion (RPE) were measured in both studies; using 2 different exercise protocols – i. cycle ergometry ii. and 6 min walk test. Both studies presented similar findings i.e. both exercise quantity and peak O_2 utilization (VO_2 max) were lower, while exertional complaints were higher in the obese group compared to the non-obese (30, 31). In the current study, mean value of VO_2 max was also lower in obese than in normal subjects, though Rate of perceived exertion (RPE) was not included in this current study.
Mota *et al* (2006) studied cardio-respiratory fitness in children aged 8 to 10 years using the '1-mile test run' (32). Marinov and Kostianev (2003) studied exercise performance in children and adolescents, aged between 6 - 17 years, using incremental treadmill test (33). Rattigan *et al* (2008) compared cardio-vascular fitness among children using '1-mile' test (34). Norman *et al* (2005) used both cycle ergometry and '12 min walk/run' test to measure exercise performance (35). Despite different protocols used in those studies, the common observations revealed that the total exercise durations were significantly shorter in the obese group compared to the non-obese group. In the present study, done with the Bruce protocol, similar findings were reported.
Chatterjee *et al* (2005) conducted a study on 10 - 16 years old schoolboys in west Bengal India, using the Queen's College step test and found that absolute VO_2 max was higher among the obese boys, but VO_2 max / kg body mass (ml/kg/min) adjusted for body mass, was less in obese than non-obese (36). Similar observations were also reported by Marinov and Kostianev (2003), where absolute values for O_2 uptake, adjusted for body mass, decreased significantly in obese compared to the non-obese (33) Hulens *et al* (2001) also reported larger absolute VO_2 (l/min) in obese women during sub-maximal exercise intensity, while terminal VO_2 (l/min/kg) was lower in obese group (30).
In the present study, VO_2 max values were derived from the total exercise duration and were expressed only as a function of total body weight. The results showed that oxygen utilization was significantly lower in the overweight group than the normal group. MET being a derived parameter from VO_2 max, also showed an identical declining trend. Hence, the current study results are in line with the findings of the above studies.
Suhas Y Shirur *et al* (2014) found that there was a highly significant negative correlation between BMI and maximal oxygen uptake, in terms of VO_2 max in their study, involving 30 obese and 30 non - obese subjects in the age group of 20 - 25 years, (37). Similar results were also observed by Laxmi CC *et al* (2014) (38) and Prabha Setty *et al* (2013) (39).
In this study, Pearson correlation analysis also exhibited significant negative correlation between BMI and VO_2 max.
Vellar *et al* (1988) in their study, involving 413 boys and 372 girls, showed that VO_2 max was significantly negatively associated with BMI and skin-fold thickness in both boys and girls and for skin-fold thickness in boys and girls (40). Pibris *et al* (2010) found a significant indirect correlation between student's VO_2 max levels and body fat while describing the trends of physical fitness related to BMI and body fat among university students between 1996 and 2008 (41) The present study also showed a significant negative correlation of both BMI and body fat %, with VO_2 max.
Shete *et al* (2014) conducted their study on 25 female athletes of age group 17- 22 years and found that, mean VO_2 max in athletic group was higher than non-athletic group, but mean body fat % was higher in non- athletic group compared to athletic group. The difference in VO_2 max and body fat % was statistically significant in the study (42)
The present study showed that mean VO_2 max was significantly lower in overweight group than normal group and showed a significant negative correlation with body fat%.
Somchit *et al* (2010) in their study, conducted on 26 male students of 26 - 31 years of age group, found that VO2 max was negatively, significantly correlated with the body fat % and the correlation was significant (43)
The present study also showed a similar kind of significant negative correlation between VO_2 max and body fat %.
Anjali S. Joshi and Kshitija Umesh Patkar (2011) in their study, involving 30 obese and 30 non-obese subjects between the age group of 18 - 20 years, concluded that the mean value of VO_2 max was less in obese group compared to non-obese respectively and there was a significant negative correlation between body fat % & VO_2 max. Their study results also showed a strong positive correlation in normal weight group between VO_2 max and fat free mass (FFM) (44). Similar result was also found in the present study; mean VO_2 max was less in obese than in normal group. VO_2 max exhibited a

significant negative correlation with body fat % and a significant positive correlation with skeletal muscle %.
The current study showed that exercise capability parameters (VO_2 max and MET) exhibited a significant negative correlation with body fat % and a significant positive correlation with skeletal muscle %. Also mean values of VO_2 max and MET were significantly higher for the normal group compared to the overweight group. Hence, the present study has validated the hypothesis that decreased physical fitness along with excess body fat leads to a decline in aerobic exercise capability as compared to normal lean subjects.
From this study, it is evident that, excess adiposity exerts an unfavorable burden as well as hindering action towards the cardiac function of individuals, leading to compromised cardiovascular fitness levels and endurance, particularly during exhaustive exercise. The reduced oxygen utilization by the adipose tissue and limitation of oxygen uptake by the working muscles lead to the decreased level of VO_2 max among overweight individuals.
However, the study was conducted on male medical students only. Hence, the cardiovascular fitness levels among the girls of the same age group remains to be evaluated through future studies. Also, the study was done in a limited area and with relatively small sample size, so global prevalence cannot be estimated.

SUMMARY & CONCLUSION

Exercise capability parameters (VO_2 max and MET) exhibited a significant negative correlation with body fat % and a significant positive correlation with skeletal muscle % in this current study, when done on young adult (18-25 years' age group) male population. Also mean values of VO_2 max and MET were significantly higher for the normal group compared to the overweight group. Hence, the present study has validated the hypothesis that decreased physical fitness along with excess body fat leads to a decline in aerobic exercise capability as compared to normal lean subjects.

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ABBREVIATIONS

TMT – Treadmill Test
MET – Metabolic Equivalent of Task or Metabolic Equivalent BF% - Body fat %
BIA – Bioelectrical impedance analysis BMI – Body mass index
FFM – Fat-free mass
RPE – Rate of Perceived Exertion ECG – Electrocardiogram

HR – Heart Rate
THR – Target Heart Rate BP – Blood pressure
SBP – Systolic Blood Pressure DBP – Diastolic Blood Pressure SD – Standard Deviation
mA – Milli-ampere
Cm - Centimeter
WC – Waist circumference WHR – Waist-hip ratio
CAD – Coronary heart disease SR – Sarcoplasmic Reticulum ATP – Adenosine Triphosphate ADP - Adenosine Diphosphate
WRAC - Women's Royal Army Corps
AIIMS – All India Institute of Medical Science WHO – World Health Organization

ANNEXURE I

QUESTIONNAIRE FORMAT

Name ………………………………………….
Age [in nearest completed years]
Personal history………………. ………………
Chief Complaints………………………………
H/o present illness ……………………………
H/o past illness ……………………………….
Drug history……………………………………
Family history of any disease……………….

GENERAL SURVEY

General Examination
Height (cm) ………………………
Weight (kg) ………………………
Pallor [clinically present or not]
Cyanosis [clinically present or not]
Clubbing [clinically present or not]
Edema [clinically present or not]
Jaundice [clinically present or not]
Blood Pressure [by Auscultatory method]
Pulse [rate & rhythm]
Cardiovascular System
Resting Heart rate (beats/min) ………………………..
Resting Respiratory rate (breaths/min) ……………….
Resting Blood pressure (mm of Hg) …………………..
Heart Sounds……………………………………………..
Respiratory System
On Inspection………………………
On Palpation……………………….
On auscultation
Breath Sounds……………
Gastrointestinal System
On Palpation………………………..
On auscultation…………………….
CNS Examination
Higher function examination…………………
Jerks and Reflexes……………………………

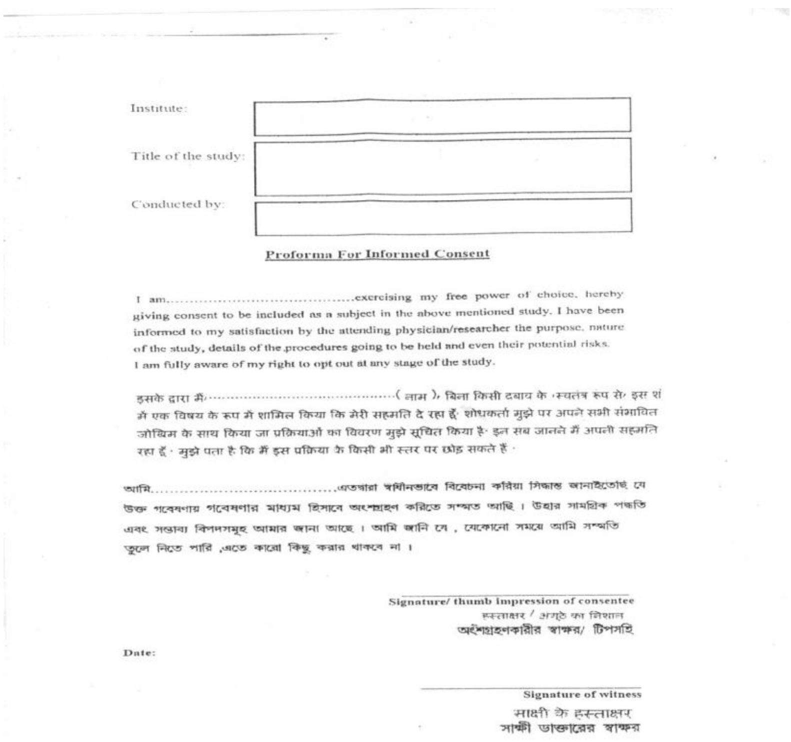
ANNEXURE II

BRUCE PROTOCOL					
Stages	Minutes	% Grade	km/h	MPH	MET's
1	3	10	2.7	1.7	5
2	6	12	4.0	2.5	7
3	9	14	5.4	3.4	10
4	12	16	6.7	4.2	13
5	15	18	8.0	~~5.0~~	15
6	18	20	8.8	5.5	18
7	21	22	9.6	6.0	20

ANNEXURE III

WHO classification of Obesity	
Classification	BMI (kg/m2)
Underweight	< 18.5
Normal Range	18.5 - 24.9
Overweight	≥ 25 - 29.9
Class I obesity	30 - 34.9
Class II obesity	35 - 39.9
Class III obesity	> 40
Indian Obesity Guidelines	
Classification	BMI (kg/m2)
Underweight	< 18.5
Normal Range	18.5 - 22.9
Overweight At Risk Obese I Obese II	≥ 23 23-24.9 25.29.9 ≥ 30

ANNEXURE IV



Institute:

Title of the study:

Conducted by:

Proforma For Informed Consent

I am.......................................exercising my free power of choice, hereby giving consent to be included as a subject in the above mentioned study. I have been informed to my satisfaction by the attending physician/researcher the purpose, nature of the study, details of the procedures going to be held and even their potential risks. I am fully aware of my right to opt out at any stage of the study.

इसके द्वारा मैं...(नाम), बिना किसी दबाव के स्वतंत्र रूप से इस शं में एक विषय के रूप में शामिल किया कि मेरी सहमति दे रहा हूँ शोधकर्ता मुझे पर अपने सभी संभावित जोखिम के साथ किया जा प्रक्रियाओं का विवरण मुझे सूचित किया है इन सब जानने में अपनी सहमति रहा हूँ मुझे पता है कि मैं इस प्रक्रिया से किसी भी स्तर पर छोड़ सकते हैं

আমি......................................এতদ্বারা স্বাধীনভাবে বিবেচনা করিয়া সিদ্ধান্ত জানাইতেছি যে উক্ত গবেষণায় গবেষণার মাধ্যম হিসাবে অংশগ্রহণ করিতে সম্মত আছি। উহার সামগ্রিক পদ্ধতি এবং সম্ভাব্য বিপদসমূহ আমার জানা আছে। আমি জানি যে, যেকোনো সময়ে আমি সম্মতি তুলে নিতে পারি ,এতে কারো কিছু করার থাকবে না।

Signature/ thumb impression of consentee
हस्ताक्षर / अंगूठे का निशान
অংশগ্রহণকারীর স্বাক্ষর/ টিপসহি

Date:

Signature of witness
साक्षी के हस्ताक्षर
সাক্ষী ডাক্তারের স্বাক্ষর

(Informed consent form approved by the Institutional Ethics Committee, NBMC & H)