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RESEARCH ARTICLE

Correlation of percentage body fat with physical efficiency index and maximal oxygen uptake

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ABSTRACT

Background: Various submaximal exercises such as Harvard step test (HST) is fairly accurate and reliable method for calculating Physical Fitness Index (PFI) and VO2 max. The PFI score can then be used to categorize the fitness level of the subject as excellent, good, average, and poor. Using recovery pulse count of HST, VO2 max can be calculated by mathematical equation. **Aims and Objectives:** Our aim and objective were to conduct HST to calculate PFI and VO2 max values from recovery pulse counts after grouping the test subjects as obese and non-obese depending on percentage of body fat. **Materials and Methods:** Ethical clearance was taken before the study and subjects were explained the procedure in detail. 20 non-obese and 20 obese subjects in the age group of 18–25 years were enrolled for the study. A 20-inch stepping platform, metronome, chair, stopwatch, wall mounted stature scope for height, and a weighing scale were used in the study. Anthropometric measurements such as height and weight were recorded. Skinfold thickness of the chest, thigh, and abdomen was measured using skinfold calipers. **Results:** On comparison of the PFI scores between two groups, the value of Chi-square was found to be 28.78 with DF=3 and $P < 0.0001$ which is extremely significant. On comparing the VO2 max values of non-obese and obese group, the value of Chi-square was found to be 30.649, with DF= 5 and $P < 0.0001$ which is extremely significant. **Conclusion:** The PFI scores were found to be much better in subjects who had less body fat percentage as compared to subjects who had body fat percentage >25%.

KEY WORDS: Physical Fitness Index; Harvard Step Test; Percentage Body Fat; Maximal Oxygen Uptake

INTRODUCTION

The prevalence of obesity is increasing due to sedentary lifestyle. Both body composition and body mass index (BMI) are parameters for assessing obesity. Various studies have shown the effect of body composition on physical fitness. Furthermore, some studies have shown percentage of body fat to be more correlated with physical fitness than BMI.

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VO2 max estimation on advanced gas analyzer equipment is not feasible. Various submaximal exercises such as Harvard step test (HST) are fairly accurate and reliable method for calculating Physical Fitness Index (PFI) and VO2 max. The PFI score can then be used to categorize the fitness level of the subject as excellent, good, average, and poor.

Maximal oxygen consumption or VO2 max is the gold standard index of cardiorespiratory fitness. It is defined as the highest rate of oxygen consumption attainable during maximal or exhaustive exercise. Using recovery pulse count of HST, VO2 max can be calculated by mathematical equation.

Our aim and objective were to conduct HST to calculate PFI and VO2 max values from recovery pulse counts after grouping the test subjects as obese and non-obese depending

on percentage of body fat. We then aimed to find if any correlation existed between the PFI and VO2 max values of the two groups.

MATERIALS AND METHODS

The study was conducted in the Department of Physiology at Indian Institute of Medical Science and Research, Warudi, Jalna. Ethical clearance was taken before the study and subjects were explained the procedure in detail. Written informed consent was taken from all the subjects. Depending on the percentage of body fat, 20 non-obese and 20 obese subjects in the age group of 18–25 years were sorted for the study.

Inclusion Criteria

Apparently healthy male subjects in the age group of 18–25 years, who volunteered to participate in the study, were included in the study.

Exclusion Criteria

Individuals suffering from any medical conditions such as diabetes, hypertension, asthma, neuromuscular disorders, and cardiorespiratory disease were excluded from the study.

Materials

A 20-inch stepping platform, metronome, chair, stopwatch, wall-mounted stature scope for height, and a weighing scale were used in the study. Anthropometric measurements such as height and weight were recorded. Skinfold thickness of the chest, thigh, and abdomen was measured using skinfold calipers. Statistical software Medcalc was used to analyze the data. Mean and standard deviation (SD) values of parameters were calculated. For correlation between variables, Chi-square test was applied. $P < 0.0001$ was considered highly significant, $P < 0.05$ was considered as significant, and $P > 0.05$ was considered as not significant.

Procedure

A 3-site skinfold thickness was used to determine percentage of body fat for selecting test subjects. Skinfold thickness of the chest, thigh, and abdomen was measured using skinfold calipers. On the basis of percentage of body fat, subjects were grouped as non-obese and obese.

The test subjects were then made to step up and down on a 20-inch stepping platform at a rate of 30 steps/min for 5 min or until exhaustion. Exhaustion is defined when the subject is not able to maintain the stepping rate for 15 s. Subjects were informed to place the foot completely onto the platform while stepping, to straighten the knee and to keep the body erect while standing on the platform. The subject was instructed to immediately sit on a chair after completing the test. Pulse count for the first 15 s was noted and multiplied by 4 to get the recovery pulse count. Furthermore, pulse was counted between 1 and 1.5 min, 2 and 2.5 min, and 3 and 3.5 min after completing the test.

The PFI score was determined by the following equation: PFI = (100 × test duration in s)/(2 × sum of heartbeats in recovery). The following equation was used to determine the subjects' VO2 max, Men = 111.33–(0.42 × pulse rate beats/min). To determine percentage of body fat, Jackson-Pollock 3-site skinfold formula was used, i.e., percentage of body fat = (0.39287 × sum of three skinfolds) – (0.00105 × [sum of three skinfolds] 2) + (0.15772 × age) – 5.18845.

PFI score was interpreted as per the following categorization.

PFI score	Fitness category (Physical condition)
>90	Excellent
80–90	Good
55–79	Average
<55	Poor

Percentage of body fat score was interpreted as per the following categorization by the American Council of Exercise.

Description	Women (%)	Men (%)
Essential fat	10–13	2–5
Athletes	14–20	6–13
Fitness	21–24	14–17
Acceptable	25–31	18–24
Obese	over 32	over 25

VO2 max score was interpreted as per fitness manual of Cooper Institute Dallas.

Age	Very poor	Poor	Fair	Good	Excellent	Superior
13–19	<35.0	35.0–38.3	38.4–45.1	45.2–50.9	51.0–55.9	55.9
20–29	<33.0	33.0–36.4	36.5–42.4	42.5–46.4	46.5–52.4	>52.4
30–39	<31.5	31.5–35.4	35.5–40.9	41.0–44.9	45.0–49.4	49.4
40–49	<30.2	30.2–33.5	33.6–38.9	39.0–43.7	43.8–48.0	>48.0
50–59	<26.1	26.1–30.9	31.0–35.7	35.8–40.9	41.0–45.3	>45.3
60+	<20.5	20.5–26.0	26.1–32.2	32.3–36.4	36.5–44.2	>44.2

RESULTS

Findings of the present study are described in Tables 1-4.

DISCUSSION

In this study, the two groups were compared, depending on the percentage of body fat to assess their PFI score and VO2

Table 1: Anthropometric measurements of non-obese and obese group

Variables	Non-obese group (mean±SD)	Obese group (mean±SD)	*P*-value	Remarks
Age (years)	21.50±2.58	21.10±2.07	0.592	NS
Height (cm)	1.67±0.06	1.64±0.05	0.088	NS
Weight (kg)	61.05±5.68	91.30±6.55	<0.0001	HS
BMI (kg/m)	21.95±1.58	33.95±1.59	<0.0001	HS
Percentage of body fat	12.4055±1.74	29.40±3.99	<0.0001	HS

BMI: Body mass index, SD: Standard deviation

Table 2: PFI and VO2 max measurements of non-obese and obese group

Variables	Non obese group (mean±SD)	Obese group (mean±SD)	*P*-value	Remarks
PFI	84.10±13.16	57.40±8.82	<0.0001	HS
VO2 max ml/kg/min	51.26±7.26	37.22±3.76	<0.0001	HS

Table 3: Comparison of PFI score of non-obese and obese group

PFI score	Non-obese	Obese
Excellent	4	0
Good	8	0
Average	8	14
Poor	0	6
Total	20	20

X=28.788; DF=3; Contingency coefficient1=0.604; *P*<0.0001 (HS).
PFI: Physical Fitness Index

Table 4: Comparison of VO2 max score of non-obese and obese group

VO2 max score	Non-obese	Obese
Very poor	0	2
Poor	0	6
Fair	1	10
Good	5	2
Excellent	6	0
Superior	8	0
Total	20	20

X=30.649; DF=5; Contingency coefficient=0.659; *P*<0.0001 (HS)

max. On comparison of the PFI scores between two groups, the value of Chi-square was found to be 28.78 with DF=3 and $P < 0.0001$ which is extremely significant. Thus, it proves that the non-obese subjects showed a significantly better PFI score as compared to obese subjects. On comparing the VO2 max values of non-obese and obese group, the value of Chi-square was found to be 30.649, with DF=5 and $P < 0.0001$ which is extremely significant. Thus, it proves that the non-obese subjects showed a significantly better VO2 max score as compared to obese subjects.

Similar results were obtained by Setty *et al*. in their study which showed a strong correlation between reduced cardiovascular performance and obesity. A study by Nor Rahimi *et al*. showed a strong correlation between body fat with fitness of rescue firefighter personnel of Malaysia. Parikh *et al*. also proved that increased visceral fat is associated with reduced aerobic fitness in Indian adolescents.

HST is a submaximal exercise test to evaluate physical fitness by mathematically estimating PFI. Furthermore, HST is a valid test to predict VO2 max which is the gold standard to predict the aerobic fitness of an individual. Thus, it is a substitute to the costly advanced air gas analyzers used to estimate VO2 max. The strength of our study is that we have compared not only PFI but also VO2 max of the same subjects as a function of percentage of body fat. We have used Harpenden Skinfold Caliper which is the gold standard for measuring skinfold thickness. Limitation of our study is a small sample size, and only male subjects were enrolled for the study.

CONCLUSION

The PFI scores were found to be much better in subjects who had less body fat percentage as compared to subjects who had body fat percentage >25%. This was established in our study with $P < 0.0001$ using "Chi-square test" when PFI was categorized as excellent, good, average, and poor. VO2 max values of the two groups when compared in terms of very poor, poor, fair, good, excellent, and superior using "Chi-square test" proved that subjects with less body fat percentage had far more better aerobic capacity than those subjects who had more body fat percentage.

BMI alone is not an absolute indicator of obesity. Percentage of body fat is strongly correlated with physical fitness and aerobic capacity. Thus, percentage of body fat should be used to categorize obesity along with other parameters. Early preventive measures and interventions along with lifestyle modifications must be made to reduce obesity as it is directly correlated with reduced physical fitness, morbidity, and mortality.

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