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Associations of Obesity Indices with Cardiorespiratory Fitness in Bengali School Going Boys in India

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ABSTRACT- This study determined the relationship between obesity parameters (Body Mass Index, Waist Hip Ratio, Waist Thigh Ratio and Body Fat Percentage) and cardio respiratory fitness in terms of physical fitness index (PFI) and also were compared the selected physiological parameters (resting pulse rate, respiratory rate and blood pressure) among three body weight categories of selected boys. The present study was carried out in 233 healthy school going Bengali boys aged 11 to <13 years from India. On the basis of Body mass index (BMI)-age-boys Z-scores, boys were categorised in three subdivisions such- normal weight, overweight, and obese. The Scheffe's multiple comparison post hoc analyses showed ($p<0.05$) significant difference of selected physiological parameters in each pair of categories. The lowest (5^{th}) to highest (95^{th}) percentiles values of PFI were higher in normal weight categories than those in over weight and obese categories. Anthropometric obesity parameters were found to have significant ($p<0.001$) and negative correlation with PFI. However, multiple regression analysis found that only body mass index and waist hip circumference (WHR) were independently and significantly associated with the physical fitness index (PFI). The present study reveals that higher values of BMI, body fat (%) and WHR may be responsible for lower score of PFI, which indicates low cardiorespiratory fitness in Bengali overweight and obese children.

Key-words- Obesity, BMI, WHR, PFI, Cardiorespiratory fitness, Boys

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INTRODUCTION

Physical fitness index (PFI) is considered as an important and valuable parameter in the field of sports and exercise physiology and is very important aspect for an individual life. BMI, body fat%, WHR are useful tools for determining obesity. Health related physical fitness of children is dependent on lifestyle related factors such as daily physical activity levels.

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It was believed that the low physical fitness level of an individual is associated with higher mortality rate [1]. Determination of PFI is one of the important criteria to assess the cardiopulmonary efficiency of a subject. Physical fitness level of an individual depends on the amount of oxygen which can be transported by the body to working muscles, and the efficiency of muscles to use that oxygen [2]. Distribution of fat centrally, with increases waist circumference thought to reflect increases in visceral fat with age [3]. The relationship between obesity indices and physical fitness index are well documented in other populations by several previous studies [4-6], which show the importance of physical fitness index in obesity management in children. Another study on the subjects of Kolkata of West Bengal in India documented similar findings [7]. BMI, body fat% and waist to hip ratio, waist to thigh ratio have been used to evaluate health risks associated with

overweight and obesity. The objectives of this study were to evaluated the relationship of PFI score with different anthropometric obesity parameters (i.e., BMI, body fat%, WHR, and WTR) and comparison of PFI score among three body weight categories of boys aged 11 to <13 years in West Bengal.

MATERIALS AND METHODS

The present study was carried-out in the 233 healthy school going Bengali boys aged 11 to <13 years. The subjects were drawn by simple random sampling from different urban private schools of mainly three districts (Bankura, Paschim Medinipur and Purba Medinipur) of West Bengal in India. On the basis of BMI- age-boys Z-scores (normal weight: -2SD > BMI, Z score < + 1SD, overweight: BMI, Z-score ≤ +2SD, obese: BMI, Z-score > +2SD), boys were categorised in three subdivisions such Normal weight, Overweight and Obese [8]. The age of the boys were determined from their date of birth as recorded in their school registered. Ethical approval and prior permission were obtained from the Institutional Ethical Committee before commencement of the study and the experiment was performed in accordance with the ethical standard of the committee. For this study, the parents of the participating boys and also head school were asked to give written approval for their boys to be involved in this research program.

Measurement of obesity parameters

Body mass index (kg.m^{-2})

BMI was calculated as the body weight in kilogram divided by height in square meters (kg.m^{-2}). For the purpose of identification of overweight and obesity of the boys the cut off values of BMI set by the World Health Organization [8] was used.

Measurement of circumferences (cm)

All the selected circumferences in the present study were measured according to the recommendation of the WHO [9]. Waist circumference was measured midway between the lower rib margin and the iliac crest. Hip circumference was measured horizontally at the level of gluteal muscle (at maximum circumference). Thigh circumference was measured as the horizontal girth at the level of the gluteal fold on the right thigh.

Computation of Body fat percentage

The skinfold thickness was measured at the right side on the triceps and subscapula with the boys standing in the proper erect posture according to the methods proposed by Johnson & Nelson [10] using Holtain skinfold calliper. For the computation of body fat % of boys were done using triceps and subscapular equation that is developed by Slaughter *et al.* [11]. The equation is as follows:

Body Fat % for boys = 783*(Triceps + Subscapular) – 1.7

Determination of physiological parameters

Blood pressure was determined using a mercury sphygmomanometer as per the recommendations of the American Heart Association [12]. The measurements were taken in a quiet room in the sitting posture with the arm resting on the table. The average of three consecutive readings was taken as the blood pressure of the child. Resting heart rate was measured after a complete rest of 3 minutes by taking the radial pulse. Three successive readings were taken in the resting state for 60 seconds each with an interval of one minute while the person was sitting. The resting respiratory rate was determined by the method mentioned by the William *et al.* [13].

Physical fitness index (PFI)

PFI was determined by Modified Harvard Step Test (HST-III). This test was done according to the method developed by Brouha and Ball [14], applied to elimentary school children. The method is as follows:

Every boy studied was advised to step up on the modified Harvard steps on 14 inches height (bench) once in every two seconds (i.e. 30 times per minute) of 3 minutes, a total of 90 steps. Post exercise recovery pulse was recorded as:

a) **Pulse rate 1** – 2 minutes after exercise
b) **Pulse rate 2** – 3 minutes after exercise
c) **Pulse rate 3** – 4 minutes after exercise

$$\textbf{PFI} = \frac{\textbf{Duration of exercise in seconds}}{\textbf{2×(Recovery pulse rate 1}^{\textbf{st}}\textbf{ + 2}^{\textbf{nd}}\textbf{ + 3}^{\textbf{rd}}\textbf{ Minutes)}} \times \textbf{100}$$

STATISTICAL ANALYSIS

All the values of anthropometric and physiological variables were expressed as Mean±SD (standard deviation). Analysis of variance (ANOVA) followed by Scheffe's multiple comparison test was performed to find out the mean difference of different anthropometric and physiological variable of different categorised. In each case the significance level was chosen at 0.05 levels. Pearson product moment correlation coefficient (r) was used to examine the co-relationship of anthropometric obesity indices with the physical fitness index. Multiple regressions were used to study the association of anthropometric obesity marker (i.e. BMI, body fat percentage, WHR and WTR) with physical fitness index (PFI). The analyses were performed using the Statistical Package for Social Sciences (SPSS, version 20.0; SPSS Inc., Chicago, Illinois, USA), and the level of significance was set to $p<0.05$.

RESULTS AND DISCUSSION

Comparison of selected anthropometric obesity parameters among three body weight categories

Comparison of selected anthropometric obesity parameters among three body weight categories of boys are presented in Table 1. One way ANOVA was performed to make an overall comparison of the selected anthropometric obesity parameters among three body weight categories. Further, Scheffe's multiple comparison tests were performed to identify significant difference in each pair of categories. It is observed from Table 1 that there existed no significant difference in height among three body weight categories. On the other hand, weight, BMI, WHR, and body fat% differed significantly ($p<0.001$) among three body weight categories. Moreover, in post hoc multiple comparison tests all pairs of body weight categories showed significant difference ($p<0.01$) among three body weight categories.

Table 1. Comparison of selected anthropometric obesity parameters among three body weight categories of boys (Normal weight boys = 125, Overweight boys = 68, Obese boys = 40)

Categories	Height (cm)	Weight (kg.)	BMI ($kg.m^{-2}$)	WHR	WTR	Body fat (%)
Normal weight (a)	147.34±3.31	36.08±2.75	16.59±0.79	0.858±0.026	1.549±0.080	14.13±2.48
Overweight (b)	146.85±3.23	46 .93±3.57	21.72±0.90	0.955±0.024	1.647±0.059	21.83±0.87
obese (c)	147.01±3.01	53.69±5.59	24.78±1.69	0.980±0.022	1.753±0.063	24.97±1.66
Level of significance	ns	***(ab)(ac)(bc)	***(ab)(ac)(bc)	***(ab)(ac)(bc)	** (ab)(ac)(bc)	***(ab)(ac)(bc)
F values	0.18	437.58	1177.29	528.13	151.57	696.34

Note: Values are Mean±SD

One way ANOVA (expressed by F value and level of significance) was performed to show the overall differences of the selected anthropometric obesity parameters among three body weight categories in 11< 13 years age group (p < 0.01, *** p< 0.001, ns= Not significant). Sceffe's multiple comparison tests were performed in every pair of three body weight categories a, b and c, where (ab) indicates 'a' significantly (p< 0.05) differed from 'b', (ac) indicates 'a' significantly (p< 0.05) differed from 'c', (bc) indicates 'b' significantly (p<0.05) differed from 'c'. BMI= body mass index, WHR = waist to hip ratio, WTR= waist to thigh ratio.**

Comparison of selected physiological parameters among three body weight categories Comparison of selected physiological parameters of three body weight categories has been presented in Table 2. The results from the Table 2 shows the significant variation ($p<0.01$) of PFI and SBP among three body weight categories. The Scheffe's multiple comparisons post hoc analysis showed ($p<0.05$) significant difference of selected physiological parameters in each pair of categories. The mean values of SBP, DBP, pulse rate and respiratory rate significantly higher in obese boys than in normal weight boys. On the other hand, mean values of PFI significantly ($p<0.01$) higher in normal weight boys than in overweight and obese boys. Earlier, Indian studies have also found PFI score of normal weight boys to be higher than in overweight and obese boys [15].

Blood pressure and adiposity in children and adolescents were assessed by Paradis *et al*. [16], and showed that resting heart (RHT) rate was increased, which suggests some degree of increased sympathetic activity, body mass index (BMI) was consistently associated with increase in SBP and DBP in all age-gender groups. The mean resting pulse rate was significantly higher in obese boys than in normal weight and overweight categories due to activation of the sympathetic nervous system occurs early in the course of obesity and the autonomic nervous system is an important contributor to the regulation of both the cardiovascular system and energy expenditure [17,18].

On the other hand, the probable reason of high respiratory rate in obese boys due to the increased adiposity around ribs, diaphragm and abdomen, leading to limited movement of ribs, decreased total thoracic and pulmonary volume causes reduction in chest wall compliance and preventing full excursion of the diaphragm [19,20].

Table 2. Comparison of selected physiological parameters among three body weight categories of boys (Normal weight boys = 125, Overweight boys = 68, Obese boys = 40)

Categories	PFI score	Resting SBP (mmHg)	Resting DBP (mmHg)	Resting pulse rate (bpm)	Resting respiratory rate (cpm)
Normal weight (a)	50.61±8.06	104.02±7.32	62.07±7.18	86.68±15.39	18.29±3.46
Overweight (b)	40.58±5.49	110.45±6.64	66.30±7.82	90.52±15.41	19.01±3.50
Obese (c)	36.87±3.32	114.42±9.24	72.45±8.60	93.9±14.58	20.35±3.97
Level of significance	**(ab)(ac) (bc)	** (ab)(ac)(bc)	* (ab)(ac)(bc)	*(ac)	* (ab)(ac)(bc)
F values	86.01	37.14	29.25	3.83	5.84

Note: Values are Mean ± SD

One way ANOVA (expressed by F value and level of significance) was performed to show the overall differences of the selected physiological parameters among three body weight categories in 11 - < 13 years age group (* p < 0.05, ** p < 0.01, ns = not significant). Sceffe's multiple comparison tests were performed in every pair of three body weight categories a, b and c, where (ab) indicates 'a' significantly (p < 0.05) differed from 'b', (ac) indicates 'a' significantly (p < 0.05) differed from 'c', (bc) indicates 'b' significantly (p < 0.05) differed from 'c'. SBP = systolic blood pressure, DBP = diastolic blood pressure, PFI = physical fitness index.

Range of PFI score among three body weight categories

Table 3 shows that the mean PFI of normal weight category was 50.61 (range 38.29 to 64.74). On the other hand, mean PFI of overweight categories was 40.58 (range 34 to 58.44). In contrary, mean PFI of obese category was 36.87 (range 32.49 to 42.58).

Table 3. Mean, standard deviation (SD), median and range of PFI scores of three body weights categories

Categories	Parameter	Mean	SD	Median	Minimum	Maximum
Normal weight	PFI	50.61	8.06	50.27	38.29	64.74
Overweight		40.58	5.49	39.48	34.0	58.44
Obese		36.87	3.32	36.66	32.49	42.58

Comparison of percentile values of PFI score among three body weight categories

Comparison of 5th, 10th, 25th, 50th, 75th, 90th and 95th percentiles of PFI scores among three body weight categories are presented in Table 4. It is observed from the Table 4 that the 5th, 10th, 25th, 75th, 90th and 95th percentile values of PFI were higher in normal weight categories than in over weight and obese categories. In contrary, the lowest (5th) to highest (95th) percentiles values of PFI were higher in overweight categories than in obese categories.

Table 4. Comparison of selected percentiles values of PFI among three body weight categories

Categories	Mean	SD	Percentiles						
			5th	10th	25th	50th	75th	90th	95th
Normal weight	50.61	8.06	40	40.54	42.85	50.27	55.90	62.5	63.38
Overweight	40.58	5.49	34.61	35.15	36.29	39.48	43.17	47.61	52.63
Obese	36.87	3.32	32.66	32.96	33.51	36.66	39.73	41.66	42.35

Determination of association BMI and body fat% with physical fitness index (PFI)

Pearson's product-moment correlation coefficients of BMI and body fat (%) with physical fitness index (PFI) were presented in Table 5. Correlation analysis showed that BMI had significant ($p<0.001$) and negative correlation with physical fitness index (PFI). In contrary, result also showed (Table 5) that body fat% had significant negative correlation ($p<0.001$) with physical fitness index (PFI). The findings of the present research confirmed the finding of these earlier studies in the present Bengali children where PFI was significantly and negatively correlated with BMI and body fat percentage [21,22]. The observed negative association between body fat percent and physical fitness index (PFI) score concur with previous studies where sophisticated techniques to measure body composition were used [23-26]. On the other hand, Gutin *et al.* [24] assessed body fat by dual energy x-ray absorptiometry (DXA) in youth and showed a negative association between body fat % and cardiorespiratory fitness in terms of PFI.

Table 5. Pearson's product moment correlation coefficient of BMI and % of Fat with PFI (No of cases: 233)

Variable	BMI(kg/m^2)			Body fat%		
	r values	95% CI	Level of significance (p)	r values	95% CI	Level of significance (p)
PFI	- 0.632	- 0.704, - 0.548	< 0.001	- 0.599	- 0.675 , - 0.51	< 0.001

Note: 2-tailed of significance was used, ns = not significance, 95 % CI = 95% confidence intervals, BMI = body mass index, PFI = physical fitness index

Determination of association of WHR and body WTR with PFI

Pearson's product-moment correlation coefficients of WHR and WTR with PFI were presented in Table 6. Pearson's product-moment correlation coefficient analysis demonstrated that WHR had significant ($p<0.001$) and negative correlation with the physical fitness index. On the other hand, result (Table 6) also shows that WTR had significant ($p<0.001$) and negative correlation with PFI. Our present finding also corroborated with the findings of Ortega *et al.* [27]; Ortega *et al.* [28] observed that physical fitness index was negatively associated with waist circumference in Swedish and Spanish youth. On the other hand, Winsley *et al*. [23] shown that visceral obesity assessed by MRI was negatively associated with cardiorespiratory fitness in children.

Table 6. Pearson's product moment correlation coefficient of WHR and WTR with PFI (no of cases: 233)

Variable	WHR			WTR		
	r values	95% CI	Level of significance (p)	r values	95% CI	Level of significance (p)
PFI	- 0.621	- 0.694, - 0.535	< 0.001	- 0.411	- 0.512, - 0.298	< 0.001

Note: 2-tailed of significance was used, ns= Not significance, 95 % CI = 95% confidence intervals, WHR= waist to hip ratio, WTR = waist to thigh ratio

Multiple linear regression analysis

Multiple linear regression analysis was performed to see whether there were independent relationships of anthropometric obesity parameters (i.e., BMI, body fat%, WHR and WTR) with PFI and standard partial regression coefficients (β) are presented in Table 7. Multiple regression analysis demonstrated that waist to hip ratio (WHR) had independent significant ($p<0.001$) negative impact on the physical fitness index (PFI), when body mass index (BMI), body fat % and waist to thigh ratio were controlled.

Table 7. In multiple regression analysis PFI is dependent variable and BMI, body fat%, WHR and WTR are independent variables

Physical fitness index (PFI) is dependent variable								
Independent Variable	**Constant (A)**	**Unstandarzied coefficient**		**Standardized coefficient**	**t**	**Level of significance (p)**	**F**	**Level of significance (p)**	**R^2**
		B	**Std. Error**	**Beta (β)**					
BMI	98.85	-1.32	0.48	- 0.53	-2.79	p<0.006	43.96	p<0.001	0.43
Body fat%		0.09	0.23	0.13	0.75	ns			
WHR		-57.52	15.70	- 0.38	-3.66	p<0.001			
WTR		-13.25	6.30	0.15	-2.10	0.036			

Note: BMI= Body mass index, WHR= Waist hip ratio, WTR = waist to thigh ratio

Hence, it appears from the present study that waist to hip ratio (WHR) is partly good detector for variability of physical fitness index (PFI) in these children. Our findings well support with previous finding in Bengali children and adolescent by Mukherjee and Dhara [21]. It was also observed from the Table 7 that even after controlling the effects of body fat %, WHR ration and WTR ratio, BMI had independent significant (p<0.006) and negative association with the physical fitness index (PFI), this finding similar as the earlier finding of Das and Dhundasi [29]. Increased central adiposity may lower utilization of oxygen per unit of body mass or respiratory trouble may occur due to higher amount fat deposition in the abdomen and chest cavity. This may restrict the proper functioning of the heart, especially during physical activities or exercises [30]. Thus, on the basis of the present study, it may be said that higher values of BMI, body fat percent and WHR may be responsible for lower score of PFI. Increased cardio respiratory fitness had been found to lower BMI, body fat (%) and WHR [30]. In light of these earlier studies and results of the present study, it may be said that obesity indices have a negative effect on cardio-respiratory fitness in terms of PFI.

CONCLUSIONS

The mean value of PFI was found to be higher in normal weight boys than in overweight and obese boys. Resting heart rate, respiratory rate and blood pressure were higher in overweight and obese children compared to normal children**.** The findings documented herein found significant negative association of obesity parameters (i.e., BMI, Body Fat%, WHR and WTR) with PFI. This indicated that a lower level of cardiovascular efficiency in overweight and obese boys compared to normal weight boys. The results of this study emphasize the need for early identification of the risk factors leading to excessive BMI, body fat% and initiation of preventive measures in order to prevent the deterioration of cardiovascular performance in 11 to <13 years old school going Bengali boys.

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