Determination of Association of Anthropometric Obesity Parameters with Cardiorespiratory Fitness in 5 to 10 Years Old School Going Bengali Boys in West Bengal

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Abstract: The present study was carried out in 770 urban healthy school going boys of 5 to 10 years of age from middle socio-economic class Bengali families by race. This study determined the association between anthropometric obesity parameters (i.e. body mass index, waist to hip ratio, waist to thigh ratio and body fat percentage) and cardio-respiratory fitness (PFI) and also were compared the selected physiological parameters (i.e. resting blood pressure, pulse rate and respiratory rate) among three body weight categories of boys. Boys were classified on the basis of BMI-age-boys-Z-scores into normal weight, overweight and obese. All the selected anthropometric obesity parameters and physiological parameters significantly varied ($p<0.001$, $p<0.05$) among three body weight categories. The lowest 5th to highest 95th percentiles values of PFI were lower in obese boys than those in normal weight and overweight boys. Obesity parameters were found to have significant negative correlation ($p< 0.001$) with PFI. Multiple regressions analysis demonstrated that there was highly significant ($p< 0.001$) and negative association of WHR with PFI when height, BMI, body fat% and WTR were constant. PFI scores and obesity indices are negatively associated. The results from this study indicate that central obesity marker (i.e. WHR) may be responsible for lower levels of PFI in overweight and obese boys. Thus, it is suggested to promote overweight and obese boys to decrease their body fat for increased cardiorespiratory efficiency.

Key words: PFI, Overweight, Obesity, BMI, WHR, Bengali boys

I. INTRODUCTION

Obesity is recognized as a major global burden to health of children **(WHO, 2000**). The rate of childhood obesity has tripled in the past two decades, and it appears to be worsening at an accelerating rate. Several cultures hold the faith that being overweight and obesity is a sign of health and wealth. The reality is, being overweight or obese increases person's risk of many chronic diseases in adult person and children are no exception (**Chinese community Health Resources Center, 2006**). The ages between five and ten years are high risk years for developing obesity. Adiposity rebound describes the inflection point between declines body mass index (BMI) and an increasing BMI that occurs between age 5 and 7 years **Bray (2008)**. Association between obesity parameters and hypertension in children has been reported in several studies among a variety of ethnic and racial groups, with almost all studies finding higher blood pressures and higher prevalence of hypertension in obese and overweight compared with normal weight children **(Verma et al. 1994, Freedman et al. 1999 and Sorof et al., 2002 and Mohan et al. 2004).**

In adults, the use of resting heart rate as screening index for cardiovascular risk has been postulated **(Palatini and Julius, 1997 and Palatini et al. 2006)**, and supported by studies that reported its relationship to mortality, independent of abdominal obesity **(Oda and Kawai, 2009).** Obese individuals tend to have a quick, shallow breathing pattern in patients with neuromuscular disorders and deformities of the chest wall. The oxygen (O_2) expenditure of breathing is a lesser amount for given ventilation when the respiratory rate is high and the tidal volume is small **(Parameswaran et al. 2006).**

Physical fitness index (PFI) is considered as an essential and important parameter in the field of sports and exercise physiology and is very vital aspect for a person life. In contrary, waist to hip ratio (WHR), waist to thigh ratio (WTR), Body mass index (BMI) and body fat% are useful tools for determining obesity of a person. Determination of Physical Fitness Index (PFI) is one of the vital criteria to measure the cardiovascular efficiency of a person. PFI level of a person depends upon on the quantity of oxygen which can be transported by the body to working muscles to utilize that oxygen **(Choudhuri et al. 2002)**.

The association between obesity parameters and physical fitness index (PFI) are well documented in other populations by numerous previous studies **(Berkey et al. 2003, Mayo et al. 2003 and Shaikh et al. 2011)** which explain the importance of physical fitness index in obesity management in children. Waist hip ratio, waist thigh ratio, BMI, and body fat % have been used to evaluate health risks linked with overweight and obesity. The main finding of the study was to understand the influence of obesity indices (i.e., BMI, body fat %, waist to hip ratio and waist to thigh ratio) on cardio-respiratory fitness in term of PFI from boys aged 5 to 10 years from state of West Bengal, India.

II. MATERIALS AND METHODS

2.1 Selection of Sites and Subjects

This cross-sectional investigation was carried out in different Urban Private Schools of mainly three districts (Bankura, Paschim Medinipur, and Purba Medinipur) of State of West Bengal of India during the period of 2012 to 2015. In this study a total 770 (number of normal weight boys = 412, number of overweight boys = 211, number of obese boys = 147) healthy school going boys having age range of 5 to 10 years from middle socio-economic class Bengali families by race were primarily selected (**Agarwal, 2008)**. The age of the children were determined from their date of birth as recorded in their school register. According to WHO growth chart **(de'Onis et al. 2008)** on the basis of BMI-age-boys Z-scores, selected boys were categorised into three sub-division such as Normal weight (- 2SD > BMI Z score ≤ + 1SD), Overweight (BMI Z-score ≤ +2SD) and Obese (BMI Z-score > +2SD). Ethical approval and prior permission were obtained from the Institutional Ethics Committee before commencement of the study and the experiment was performed in accordance with the ethical standards of the committee and with the Helsinki Declaration. Prior to the experimental trial each protocol was explained verbally in local language (Bengali) to the subjects and school authorities and informed consent was obtained from the participants. For this study, parents of the participating boys and also head of the school were asked to give written approval for their boys to be involved in this research programme. The measurements were taken on the same day or another as per their agreement by fixing prior appointments.

2.2 Measurement of Anthropometric Obesity Parameters

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

BMI was calculated as the body weight in kilogram divided by body height in square meters (kg.m^{-2}). Identification of overweight and obesity in the boys were performed by plotting BMI value on the WHO growth chart to determined the corresponding BMI-age-boys Z scores **(de'Onis et al. 2008)** and also following the proposed guidelines by **Cole et al. (2002)** for children with BMI ≥ 95th percentile are obese and those with BMI ≥ 85th percentile but < 95th percentile are defined overweight.

2.2.2 Measurement of circumferences (cm)

All the selected circumferences in the present study were measured according to the recommendation of **WHO (1989).** 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. In all measurements the subjects were standing with their weight evenly balanced on both feet and the distance between the feet about 30 cm apart. The subjects were asked to breathe normally and, at the time of measuring to breathe out gently.

Calculation of Waist to Hip Ratio (WHR) and Waist to Thigh Ratio (WTR)

$$\text{WHR} = C_W / C_H$$

Where, C_W = Waist circumference, C_H = Hip circumference

$$\text{WTR} = C_W / C_T$$

Where, C_W = Waist circumference, C_T = Thigh circumference

2.2.3 Measurement of body fat percentage

For measurement of body fat percentage, skinfold thickness were measured at the right side on the triceps and sub-scapula with the boys standing in the proper erect posture according to the methods proposed by **Eston et al. (1995)** using Holtain skinfold callipers which consists of accurately calibrated dial which indicates in millimetre. Computations of body fat% of boys were done using triceps and subscapular equation that is developed by **Slaughter et al. (1988)**.

The equation is as follows:

Body fat % for boys = 783*(triceps skinfold thickness + subscapular skinfold thickness) –1.7

2.3 Determination of Physiological Parameters

2.3.1 Determination of blood pressure (mmHg)

Blood pressure was measured using standard auscultatory method in sitting position after rest period of the subjects. Blood pressure was measured by mercury sphygmomanometer. The systolic blood pressure (SBP) was recorded at the appearance of first 'Korotkoff' sound and the diastolic blood pressure (DBP) was assured at the disappearance of the 'Korotkoff' sounds.

2.3.2 Determination of pulse rate (beats.min^{-1})

Pulse rate was measured by using a stop watch in sitting position after rest period of the subjects. The tips of the three fingers were placed on the radial artery at wrist. The pulse count was continued for 60 seconds duration. The number of beats counted was recorded as beats per minute (bpm).

2.3.2 Determination of respiratory rate (cycle.min^{-1})

Respiratory rate was determined by the method mentioned by **William et al. (2006)**. Respiratory rate was counted by using a stop watch in sitting position after rest period of the subjects. The respiratory rate count was continued for 60 seconds duration. The respiratory rate was recorded as cycle per minute (cpm).

2.3.3 Physical fitness index (PFI)

Physical fitness index was determined by Modified Harvard Step Test. This test was done on Modified Harvard Steps (HST-III) according to the method mentioned by **Brouha & Ball (1952)** for applicable to school children. The method is as follows:

Every boy studied was advised to step up on the modified Harvard steps of 12 inches height once in every two seconds for 3 minutes, a total of 90 steps. Post exercise recovery pulse was recorded as:

a) Pulse Rate 1– 2 min after exercise

b) Pulse Rate 2 – 3 min after exercise.

c) Pulse Rate 3 – 4 min after exercise

$$\text{Physical fitness index (PFI)} = \frac{\text{Duration of exercise in seconds}}{2 \times (\text{recovery pulse 1st+2nd+3rd minutes})} \times 100$$

III. STATISTICAL ANALYSIS

Data analysis was performed using the statistical packages IBM SPSS, version 20 SPSS, (Chicago, USA). Mean, standard deviation (± SD), median, range, percentile ranking were obtained for PFI of three body weight categories in 5 to 10 years age group of boys. In each cases significant level were chosen at 0.05 levels. One way ANOVA was conducted to examine any differences in each variable among three body weight categories. Post hoc multiple comparison tests (Scheffe's F test) were performed for each of the variables to see the significance of the differences in each pair of groups where F values in one way ANOVA were significant. Pearson product moment correlation coefficients (r) were performed to examine the relationship of different anthropometric obesity parameters with the PFI. The 'standard partial regression or standardized coefficient' of multiple linear regression analyses were used to show the independent relationship of BMI, fat percentage, waist hip ratio and waist to thigh ratio with PFI.

IV. RESULTS AND DISCUSSIONS

4.1 Comparison selected anthropometric obesity parameters among three body weight categories of boys

The mean and standard deviation of selected anthropometric obesity parameters of selected boys are presented Table 4.1. One way ANOVA was performed to create an overall comparison of the selected anthropometric obesity indices among three body weight categories boys. In addition, Scheffe's multiple comparison tests were performed to identify significant difference in each pair of category of boys. It is noted from the Table 4.1 that there existed no significant difference in body height among three body weight categories of boys. On the contrary, body weight, body mass index (BMI), waist to hip ratio (WHR), and body fat% varied significantly ($p<0.001$) among normal weight, overweight and obese boys. Furthermore, in Scheffe's post hoc multiple comparison tests all pairs of body weight categories showed significant variance ($p<0.001$) of above mentioned parameters among three body weight categories of boys.

Table 4.1 Comparison of selected anthropometric obesity parameters among three body weight categories of boys (number of normal weight boys = 412, number of overweight boys = 211, number of obese boys = 147)

Categories	Body height (cm)	Body weight (kg.)	BMI (kg.m^{-2})	Body fat%	WHR	WTR
NW (a)	124.87±9.74	24.59±4.67	15.60±0.86	12.90±2.08	0.889±0.032	1.670±0.099
OW (b)	125.45±9.81	29.84±6.02	18.72±1.01	19.99±2.52	0.981±0.026	1.708±0.118
OB (c)	126.39±9.76	35.35±7.93	21.78±1.75	24.42±4.27	0.998±0.024	1.787±0.103
Level of significance	ns	*** (ab)(ac)(bc)	*** (ab)(ac)(bc)	*** (ab)(ac)(bc)	*** (ab)(ac)(bc)	** (ab)(ac)(bc)
F values	1.28	194.23	1716.76	1090.65	1036.78	64.72

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 5 - 10 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; NW = normal weight; OW = over weight;, OB = obese*

4.2 Comparison of selected physiological parameters among three body weight categories of boys

Comparison of selected physiological parameters of three body weight categories of boys has been presented in Table 4.2. It was found that PFI, RRR, RBP and RPR differed significantly among three body weight categories. Moreover, Scheffe's multiple comparisons post hoc analysis showed significant difference ($p<0.05$) of all selected physiological parameters (i.e. PFI, resting blood pressure, pulse rate and respiratory rate) in each pairs of categories. In this study the mean physical fitness index (PFI) score for normal weight categories significantly higher as compared to the overweight and obese children. This may be due to higher body mass, BMI and body fat percentage of overweight and obese boys. Result of this study similar as to the **Misra et al.** study **(2017)** in adolescent boys. Their study also has reported that higher PFI score in normal weight children than in overweight and obese children. The analysis of others physiological parameters such as RRR, RPR, RSBP and RDBP in three categories differs from each other. Obese children show a significant increase in RRR, RPR, RSBP and RDP in all physiological parameters compared to normal weight and obese categories.

Table 4.2 Comparison of selected physiological parameters among three body weight categories of boys (number of normal weight boys = 412, number of overweight boys = 211, number of obese boys = 147)

Categories	RPR(bpm)	PFI	RRR(cpm)	RSBP (mmHg)	RDBP (mmHg)
NW (a)	87.66±14.50	53.04±7.76	19.70±2.20	96.80±6.31	58.20±7.55
OW (b)	90.11±16.20	45.15±6.48	21.64±3.82	99.75±8.44	61.43±8.78
OB (c)	92.92±17.49	41.12±4.90	24.75±4.58	103.20±9.98	64.34±10.60
Level of significance	*(ab)(ac) (bc)	***(ab)(ac)(bc)	*(ab)(ac)(bc)	*(ab)(ac)(bc)	*(ab)(ac)(bc)
F values	4.42	145.55	16.01	25.04	21.09

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 5 - 10 years age group of boys ($p < 0.05$, ** $p < 0.01$, 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'. PFI = physical fitness index; RSBP = resting systolic blood pressure; RDBP = resting diastolic blood pressure; RPR = resting pulse rate; RRR = resting respiratory rate; NW = normal weight; OW = over weight; OB = obese*

Resting blood pressure and obesity in children and adolescent were measured by **Paradis et al. (2004)** and they showed that resting pulse rate was increase in obese children which suggest a few degree of increased sympathetic activity, body mass index (BMI) was consistently associated with increase in SBP and DBP in all age groups.

The mean resting pulse rate was significantly higher in obese boys than in normal weight and overweight categories might be due to activation of the sympathetic nervous system that occurs early in the course of obesity and it was reported that the autonomic nervous system is an vital contributor to the regulation of both the cardiovascular system and energy expenditure **(Benjamin and Levy, 1999).** In contrast, obesity has a profound effect on the physiology of breathing. An important respiratory abnormality in obesity is a decrease in total respiratory system compliance, which is supported by the work of **Naimark and Cherniack (1960)**. They have established that total respiratory compliance is decreased by as much as two-thirds of the normal value in obese individuals.

4.3 Descriptive statistics of PFI of three body weight categories of boys

It is observed from the Table 4.3 that mean PFI of normal weight boys was 53.04 (median 52.94; range 40.17 to 70.86). On the other hand, mean PFI of overweight boys was 45.15 (median 43.17; range 34.09 to 65.21. Moreover, mean PFI of obese boys was 41.12 (median 41.66; range 33.33 to 52.02).

Table 4.3 Mean, standard deviation (SD), median and range of PFI of three body weight categories of boys

Categories	Parameter	Mean	SD	Median	Minimum	Maximum
Normal weight	PFI	53.04	7.76	52.94	40.17	70.86
Overweight		45.15	6.48	43.47	34.09	65.21
Obese		41.12	4.90	41.66	33.33	52.02

Table 4.4 Comparison of selected percentiles values of PFI among three body weight categories of boys

Categories	Mean	SD	Percentile						
			5th	10th	25th	50th	75th	90th	95th
Normal weight	53.04	7.76	41.09	42.85	46.51	52.94	58.82	64.74	65.69
Overweight	45.15	6.48	35.15	35.43	40.00	43.47	51.72	54.87	59.60
Obese	41.12	4.90	33.58	34.61	37.03	41.66	44.77	47.87	49.72

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

Comparison of selected percentiles (i.e. 5th, 10th, 25th, 50th, 75th, 90th, and 95th) of PFI scores among three weight categories of boys are presented in Table 4.4. It is noted from the Table 4.4 that all the selected percentile values (i.e. 5th, 10th, 25th, 50th, 75th, 90th, and 95th) of PFI were higher in normal weight category than in over weight and obese category. On the other hand, the lowest (5th) to highest (95th) percentiles values of PFI scores were higher in overweight category than in obese category.

Table 4.5 Pearson's product moment correlation coefficient of body height with PFI

Variable	Height (N=770)		
	r	95% CI	Level of significance
PFI	-0.090	-0.177, -0.002	P< 0.04

Note: ns = not significance, 95 % CI = 95% confidence intervals

4.5 Determination of association of body height with physical fitness index (PFI)

Pearson's product-moment correlation coefficients body height with physical fitness index (PFI) was presented in Table 4.5. Pearson's product-moment correlation coefficient analysis demonstrated that body height had significant ($p<0.04$) and negative correlation with PFI.

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

Pearson's product-moment correlation coefficients of body mass index (BMI) and body fat% with physical fitness index (PFI) were presented in Table 4.6. Correlation analysis demonstrated that BMI and body fat percentage had significant ($p<0.001$) and negative correlation with physical fitness index (PFI). Result of this finding similar as to the **Misra et al** study **(2017)** in Bengali adolescent boys, where PFI was significantly and negatively correlated with the body mass index and body fat percentage. The observed negative relationships between body fat percentages with physical fitness index agree with earlier studies **(Mukherjee & Dhara, 2014; Winsley et al. 2006; Lee & Arslanian, 2007),** they showed an inverse relationship of body fat percentage with physical fitness scores.

Table 4.6 Pearson's product moment correlation coefficient of BMI and % of Fat with physical fitness index (PFI)

Variable	BMI (N = 770)			Body fat% (N = 770)		
	r	95% CI	Level of significance	r	95% CI	Level of significance
PFI	-0.553	-0.661, -0.488	P< 0.001	-0.534	-0.594, -0.468	P< 0.001

Note: ns = not significance, 95 % CI = 95% confidence intervals

Table 4.7 Pearson's product moment correlation coefficient of WHR and WTR with PFI

Variable	WHR (N = 770)			WTR (N = 770)		
	r	95% CI	Level of significance	r	95% CI	Level of significance
PFI	-0.467	-0.533, -0.395	p< 0.001	-0.325	-0.401, -0.244	p< 0.001

Note: ns = not significance, 95 % CI = 95% confidence intervals

4.7 Determination of association of WHR and WTR with physical fitness index (PFI)

Pearson's product-moment correlation coefficients (r) of waist to hip ratio (WHR) and waist to thigh ratio (WTR) with physical fitness index (PFI) were presented in Table 4.7. A significant negative ($p< 0.001$) between PFI scores with WHR ratio was noted. Similarly, a significant ($p< 0.001$) negative correlation was observed between PFI scores and WTR. The results of this study showed that there is a significant negative relationship between central obesity marker WHR and PFI. **Ortega et al. (2010)** examined the adiposity in children and adolescent, they observed that PFI was inversely associated with the waist to hip ratio. **Bovet et al. (2007)** examined the association between obesity indices and PFI and they reported a strong negative relationship between physical fitness score and higher body mass in adolescents. On the other hand, **Winsley et al. (2006)** showed that abdominal obesity assessed by Magnetic Resonance Assay (MRI) was negatively associated with PFI in children. Most of the studies have reported a significant inverse relationship between obesity indices and cardio-respiratory fitness in terms of PFI. Overall, the results of the present study support this negative association. Based on the present report and the literature, we can conclude that there is a significant and negative relationship between central obesity marker WHR and PFI.

Table 4.8 Multiple regression analysis of PFI on BMI, body fat%, WHR and WTR

Physical fitness index (PFI) is dependent variable									
Independent Variable	Constant (A)	Unstandarzied coefficient		Standardized coefficient	t	Level of significance	F	Level of significance	R^2
		B	Std. Error	Beta (β)					
Height	106.46	-0.105	0.056	-0.077	-1.786	p<0.060	49.04	p<0.001	0.334
BMI		-0.774	0.252	-0.284	-3.077	p<0.002			
Body fat%		-0.162	0.123	-0.124	-1.320	ns			
WHR		-17.821	5.544	-0.171	-3.215	p<0.001			
WTR		-5.710	3.840	-0.068	-1.487	ns			

4.8 Multiple linear regression analysis

Multiple linear regression analysis was performed to see whether there were independent relationships of obesity indices with physical fitness index (PFI) and standard partial regression coefficients (β) are presented in support of that (Table 4.8). It is observed from Table 4.8 that waist to hip ratio (WHR) had independent significant ($p<0.001$) and negative relationship with cardio-respiratory fitness in term of PFI when height, BMI, body fat percentage and waist to thigh ratio (WTR) were controlled. So, waist to hip ratio (WHR) is partly good detector for variability of PFI compared to BMI, WTR and body fat. These observations were in agreement with earlier studies on Bengali children in which similar results were obtained **(Mukherjee & Dhara, 2014; Misra et al. 2017).** These results of the present study showed that waist to hip ratio (WHR) to be a better predictor of variability of PFI. This study also showed that higher PFI scores may be related with lower values of BMI, body fat percentage and WHR. This implied that greater physiological fitness may lower the vulnerability of boys to develop early obesity. Increased fat mass may poorer utilization of oxygen per unit of body mass. It may restrict appropriate functioning of heart particularly during physical exercises **(Bandyopadhyay, 2012).**From this present study it may be concluded that low PFI scores may result in higher mean values of WHR, body fat % and BMI which may be negative impact to cardio-respiratory fitness. Increased cardio-respiratory fitness in term of PFI scores had been found to lower WHR, BMI and body fat percentage **(Bandyopadhyay, 2012; Chikuji et al. 1999).** From these previous studies and results of the current study it may be concluded that anthropometric obesity parameters has a negative impact on cardio-respiratory fitness in term of PFI of this boys.

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VI. FUNDING INFORMATION

There is no finding source for this study.

VII. CONFLICT OF INTERESTS

The authors declared that there is no conflict of interest.

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