Academic Sciences Asian Journal of Pharmaceutical and Clinical Research

Vol 5, Suppl 2, 2012 ISSN - 0974-2441

Research Article

RECEIVER OPERATING CHARACTERISTIC (ROC) ANALYSIS IN PRE-MENARCHEAL PUNJABI GIRLS TO DETECT EXCESS ADIPOSITY

BADARUDDOZA* AND SHRUTI CAPLASH

Department of Human Genetics, Guru Nanak Dev University Amritsar-143 005, Punjab, INDIA, Email: doza13@yahoo.co.in

Received:23 January 2012, Revised and Accepted:22 April 2012

ABSTRACT

The study was designed to determine excess adiposity in pre-menarcheal Punjabi girls using anthropometric indicators through receiver operating characteristic analysis. A total of 587 pre-menarcheal girls aged 8 to 12 years were recruited for present study. Four anthropometric indicators such as body mass index, waist circumference, waist hip ratio and skinfold thickness have been used to compare. Receiver operating characteristics (ROC) analysis was done to assess the sensitivity and specificity of the different anthropometric indicators for detecting excess adiposity in pre-menarcheal children. The result of the present study has indicated that waist circumference, waist hip ratio and triceps skinfold thickness were better indicator for screening in girl children aged 8 to 12 years as it is reflected in the calculated area under ROC analysis.

Keywords: ROC analysis, anthropometric indicators, adiposity, pre-menarcheal girls, India.

INTRODUCTION

Excess body fat is the outcome of obesity. Childhood overweight and obesity is significantly associated with an increased risk of chronic cardiovascular disease (CVD) risk factors early stage of life[1,2] and its presence over time may boost adverse adult CVD risk profiles.[3] Childhood and adolescents obesity for the last couple of decades has become a predominant health issue both in developed and developing countries.[4,5] It has been suggested that overweight children may become overweight adults if obesity persists in adolescence.[6] Thus, primary and secondary prevention of obesity is an urgent concern to public health.[7,8] However, it is noteworthy to mention that the intervention of childhood obesity might not be possible unless the early tracking is done appropriately. Generally, body mass index (BMI) has been used to track obesity in children because a significant association between BMI and excess body fat mass has been found. Otherwise, one could utilize sensitivity and specificity of BMI, and skinfold thickness to detecting excess mass in children. A number of studies have already reported that BMI generally has low sensitivity as compared to skinfolds in tracking excess adiposity among children and adolescents.[9-12] However, the use of BMI for screening and prevention of obesity remains problematic in India where CVD in adults occurred with lower BMI and percentage of body fat with higher trunk skinfolds and central obesity as compared to global populations.[13-14] The prevalence of obesity in all age groups posses such a serious problem that World Health Organization[15] has described it as a 'global epidemic'. According to Warriach *et al.*[16], there are 1 billion overweight people in the world, of whom 300 million are obese. American Medical Association reported that 15% of 6-19 years old children in the U.S. are overweight, and that rates of childhood obesity have been steadily increasing since the 1970's.[17] A child is considered as obese when the total body weight is more than 25 percent fat in boys and 32 percent in girls.[18] In India, there is an increasing trend to overweightness, obesity and cardiovascular diseases among children and adolescents due to sedentary lifestyle and changed food habits especially in urban affluent society.[19-21] Obesity in children appears to increase the risk of occurrence of various chronic degenerative disorders such as hypertension, type 2 diabetes mellitus, coronary artery disorder, stroke, orthopedic disorder and depression.[10,22,23] Therefore, trends in childhood obesity need to be closely monitored, and in 2000, World Health Organization has proposed new ranges of measuring obesity for Asians for associated risk factors. However, the usefulness of these proposed cut-off points of different anthropometric indicators depends on its predictive strength of excess body fat, this can be done by Receiver Operating Characteristic (ROC) Curve analysis by measuring its sensitivity and specificity. This is an important issue for Indians, as increased health risks are associated with lower BMI.[24] ROC analysis offers a systematic and well-understood way to evaluate different anthropometric indicators and other factors on age specific comparison among adolescents. Therefore , in view of above consideration, the present work was undertaken with following objective to evaluate excess adiposity in pre-menarcheal Punjabi girls aged 8-12 years through Receiver Operating Characteristic (ROC) analysis.

MATERIALS AND METHODS

Study sample: The present cross sectional study was conducted during the period of August, 2009 to February, 2010. A total of 587 healthy pre-menarcheal girls aged 8 to 12 years were recruited for the present study to detect excess adiposity. Girls from different schools of Kapurthala, Phagwara and Amritsar districts were included in the study. The total sample were further distributed through age group such as 115 for 8 years, 125 for 9 years, 121 for 10 years, 117 for 11 years and 109 for 12 years girls. The present study was approved by the University Appropriate Research Ethics Committee. Written consent was obtained from parents and principals before work commenced.

Anthropometric Measurements

The anthropometric measurements taken were height (cm), weight (kg), waist circumference (cm), hip circumference (cm), upper arm circumference (cm) and four skinfolds such as biceps skinfold, triceps skinfold, sub-scapular skinfold and suprailiac skinfold. All the anthropometric measurements were taken on each individual using standard anthropometric technique.[25,26] The age of the individuals was determined directly from their reported date of birth. The height measures the vertical distance from the point vertex to the base of the heels using anthropometric rod. The reading was recorded to the nearest 0.1 cm. The weight of the subject was measured in kilograms by making him stand on a weighing machine with minimal clothing. Weight was recorded with an allowance deducted for clothing. Waist circumference was measured using a steel tape. The subject was asked to stand erect with feet 25-30 cm apart and weight evenly distributed and with her abdomen relaxed. The measurement is taken mid-way between the inferior margin of the last rib and the crest of the ilium in a horizontal plane. Hip circumference of the subject was taken with steel tape fitted around the pelvis at the point of maximal protrusion of buttocks while the subject was standing with her feet close to each other. The measurement of mid upper arm circumference is taken with steel tape. It measures the maximum circumference of upper arm taken horizontally i.e. where the biceps muscles are most developed. Skinfold measurement is a means of estimating the amount of the mass of body fat. They are important in study of body composition and for the assessment of nutritional status as these skinfold thickness reflect the development of adipose tissue or fatty tissue overlying the body as well as general obesity. The skinfold is picked up between thumbs and middle finger with the caliper jaws applied exactly at the level marked. Four skinfolds were taken such as biceps

skinfold, triceps skinfold, subscapular skinfold and suprailiac skinfold. All skinfold thickness was taken with the help of Harpenden's calipers. Body mass index was calculated by dividing weight of the subject in kilograms by square of her height in meter (BMI = Weight (kg)/ Height^2 (m)^2).Waist to hip ratio is calculated by the formula given below: WHR = Waist circumference (cm)/ Hip Circumference (cm).

Statistical analysis

A receiver operating characteristics (ROC) analysis is a technique to compare the accuracy of different diagnostic tests. In the present context of the study the accuracy of the test refers to different anthropometric indicators to discriminate the obesity to non obesity. The ROC analysis also allows us to explore the relationship between the sensitivity and specificity of a diagnostic test with a variety of different cutoff points, which helps to identify of an optimal cutoff point. Sensitivity of an anthropometric indicator is the probability that the anthropometric indicator will diagnose the subject as obese when it is actually present (the true positive rate). Specificity is the probability that we identify that the obesity is absent when it is truly absent (the true negative rate). When for every possible cut-off point of an anthropometric indicator selected to discriminate between obese and nonobese in the two populations, then there will be some cases with the disease correctly classified as positive (TP = True Positive fraction), but some cases with the disease will be classified as negative (FN = False Negative fraction). On the other hand, some cases without the disease will be correctly classified as negative (TN = True Negative fraction), but some cases without the disease will be classified as positive (FP = False Positive fraction). Actually sensitivity and specificity are defined as the number of true positive decisions/ the number of actually positive cases and the number of true negative decisions/ the number of actually negative cases, respectively. The receiver operating characteristic (ROC) curve, which is also defined as a plot of test sensitivity as the y coordinate versus its 1-specificity or false positive rate (FPR) as the x coordinate to estimate the best cutoff values of diagnostic tests.[27] One index reflecting the overall accuracy of the diagnostic test derived from an ROC analysis is the area under the curve (AUC).[9,28] The ideal area under the curve (AUC) is of 1 however, it can take on any value between 0 and 1 such as for example, an AUC of 0.9 means that a randomly selected obese subject has a diagnostic test value larger than that of a randomly selected nonobese subject 90% of the time.[29] The classifications of Area under ROC are as follows[28]:(i) Area= 0.90 – 1.0 considered Excellent (ii) Area= 0.80–0.90 considered Good (iii) Area= 0.70 – 0.80 considered Fair iv) Area= 0.60 – 0.70 considered Poor (v) Area= < 0.60 considered Worthless. Therefore, ROC analysis provides better estimates of sensitivity, specifity and AUC. All the statistical analyses were performed using the statistical package for Social Sciences (SPSS, Version 16.0). A p-value of <0.05 (two-tailed) was considered as significant.

RESULTS

Descriptive statistics for anthropometric variables are presented in table 1 among pre-menarcheal Punjabi girls of 8 to 12 years of age. The maximum mean values for waist-to-hip ratio (0.92), biceps skinfold (3.87 mm) and triceps skinfold (5.86 mm) were found in 8 year girls; whereas the maximum values for BMI (16.51 kg/m^2), waist circumference (54.60 cm), hip circumference (62.21 cm), upper arm circumference (17.49 cm), sub-scapular skinfold (6.34 mm) and suprailiac skinfold (6.23 mm) were found in 11 year girls. However, the maximum mean values of height (138.85 cm) and weight (31.22 kg) were found in 12 year girls. The variances (SD^2) of almost all studied characters consistently increase with the increase of age. Almost all the data of all variables in every age group have shown right skewed distribution (Skewness>0) which means most values are concentrated on left of the mean with extreme values to the right. Few distributions of the data of the parameters such as waist-to-hip ratio (8 to 11 years), height (9 and 11 years) and weight (12 years) have shown left skewed distribution (Skewness<0)which means that these values are concentrated on the right of the mean with extreme values on the left. Therefore, it may be assumed that all the distributions are symmetrical around the mean. Whereas, the values of Kurtosis have been seen <3 in almost all the parameters in every age group indicating the probability for extreme values is less than for a normal distribution and the values are wider spread around mean. However, very few data like suprailiac skinfold (9 years), triceps skinfold (10 years), body mass index and upper arm circumference (12 years) the kurtosis have been found >3 which indicated the values concentrated around the mean and thicker tail with high probabilities of extreme values.

Tab

Table 1: Physical characteristics of pre-menarcheal Punjabi girls aged 8-12 years

	8 yrs. (N=115)			9 yrs. (N=125)			10 yrs. (N=121)			11 yrs. (N=117)			12 yrs. (N=109)		
	Mean±SD	Ske	Kur	Mean ±SD	Ske	Kur	Mean ±SD	Ske	Kur	Mean ±SD	Ske	Kur	Mean±SD	Ske	Kur
Height (cm)	119.55±5.48	0.23	0.11	124.84±6.08	-0.21	0.20	129.94±7.11	0.01	0.32	136.25±7.39	-0.03	0.47	138.85±8.06	-0.50	0.34
Weight (kg)	22.11±4.48	1.35	2.17	23.74 ±4.28	0.81	1.45	26.38±5.12	0.89	0.64	30.89 ±6.06	0.44	0.26	31.22±7.04	1.12	2.05
BMI (kg/m^2)	15.36±2.18	1.06	1.12	15.14 ±1.96	0.76	1.51	15.52±1.94	0.85	0.80	16.51 ±2.18	0.80	0.52	16.04±2.47	2.02	7.14
WC (cm)	51.43±4.28	0.94	1.67	51.29 ±4.34	0.76	0.16	52.43±4.89	0.81	0.94	54.60 ±5.44	0.62	0.35	54.15±5.63	1.12	1.89
HC (cm)	55.46 ±4.54	1.12	2.67	56.67 ±4.45	0.69	0.33	58.98±5.52	0.69	0.82	62.21 ±6.85	0.89	0.98	61.18±6.28	0.87	1.01
WHR	0.92 ±0.38	-0.06	0.44	0.90 ±0.04	-0.55	0.45	0.88±0.04	-0.37	0.27	0.87 ±0.04	-0.01	0.20	0.89±0.03	0.36	0.48
UAC (cm)	15.76±1.58	0.90	0.71	16.08±1.85	0.76	0.69	16.54±1.81	0.47	0.20	17.49±1.76	0.48	0.17	17.30±2.38	1.08	5.67
BSF (mm)	3.87±1.35	0.79	0.93	3.74±1.44	1.16	1.88	3.79±1.42	0.84	0.49	3.61±1.32	1.07	1.79	3.77±1.55	1.17	1.35
TSF (mm)	5.86±1.63	0.51	0.48	5.58±1.83	1.29	2.48	5.63±1.78	1.51	3.88	5.54±1.38	0.73	1.65	5.42±1.73	0.93	0.89
SSSF (mm)	5.96±2.12	1.13	2.27	5.93±1.92	1.18	2.51	5.93±1.79	0.86	1.05	6.34±1.86	0.45	0.19	5.92±1.96	0.58	0.31
SISF (mm)	5.93±2.14	0.87	1.39	5.72±2.06	1.54	3.43	5.84±2.06	0.73	0.14	6.23±1.86	1.07	1.78	6.02±1.89	0.49	0.24

BMI=Body Mass Index; WC=Waist Circumference; HC=Hip Circumference; WHR=Waist to hip ratio; UAC=Upper arm circumference; BSF=Biceps skinfold; TSF=Triceps skinfold; SSSF=Subscapular skinfold; SISF=Suprailiac skinfold; Ske=Skewness; Kur=Kurtosis

Table 2 represents the percent distributions of normal, overweight and obese pre-menarcheal Punjabi girls using different anthropometric indices. The result shows that supra-iliac skinfold for 8 years, biceps skinfold for 9 years; upper arm circumference and subscapular skinfold for 10 years; waist hip ratio for 11 years and subscapular skinfold for 12 years are more prominent indicators to classify overweight pre-menarcheal girls. Whereas, biceps skinfold for 8 years and 10 years; waist circumference for 9, 11 and 12 years are more significant indicators to classify obese pre-menarched girls. Hence overweight and obesity are more frequent in pre-menarcheal

Punjabi girls according to skinfold thickness, waist circumference and waist hip ratio.

Table 3 represents optimal sensitivity, specificity and positive likelihood ratio among pre-menarcheal Punjabi girls of 8 to 12 years. Among 8 year girls, almost all indicators especially body mass index, waist circumference, waist-to-hip ratio etc have high specificity > 98% whereas sensitivity have been found minimum for all these parameters. However, positive likelihood ratios have been found maximum in waist circumference (34.28 cm). Therefore, waist circumference may be considered as best indicator with high specificity and likelihood ratio to identify adiposity among 8 years girls. All the indicators among 9 years have high specificity. Maximum positive likelihood ratio has been found for body mass index (51.9 kg/m^2). Therefore, body mass index may be considered as good indicator for 9 years girls. Among 10 year girls, the sensitivity of all parameters has been found lower whereas higher specificity for almost all parameters has been observed. The maximum positive likelihood ratio has been seen in upper arm circumference (37.5 cm) as well as in waist-to-hip ratio (33.3) and triceps skinfold (33.3 mm). Therefore, upper arm circumference, waist-to-hip ratio and triceps skinfold could be considered equally good indicators to identify adiposity for 10 years girls. Among 11 and 12 year girls, the same trend for sensitivity and specificity have been observed as it was observed in previous years. The maximum positive likelihood ratios are found in biceps skinfold (15.62 mm) for 11 years and in subscapular skinfold (13.89 mm) for 12 year girls. Therefore, biceps skinfold and subscapular skinfold would be considered good indicators to identify adiposity among 11 and 12 year girl respectively.

Table 2: Percentage distributions of normal, overweight and obese through different anthropometric indicators in pre-menarcheal Punjabi girls aged 8-12 years.

VARIABLES	NORMAL					OVERWEIGHT					OBESE				
	8 yrs	9 yrs	10 yrs	11 yrs	12 yrs	8 yrs	9 yrs	10 yrs	11 yrs	12 yrs	8 yrs	9 yrs	10 yrs	11 yrs	12 yrs
BMI (kg/ m^2)	100 (87.0)	118 (94.4)	114 (94.2)	103 (88.0)	95 (87.2)	12 (10.4)	7 (5.6)	7 (5.8)	10 (8.5)	7 (6.4)	3 (2.6)	0 (0)	0 (0)	4 (3.4)	7 (6.4)
WC (cm)	98 (85.2)	112 (89.6)	104 (86)	99 (84.6)	89 (81.7)	11 (9.6)	7 (5.6)	11 (9.1)	8 (6.8)	11 (10.1)	6 (5.2)	6 (4.8)	6 (5)	10 (8.5)	9 (8.3)
WHR	99 (86.1)	108 (86.4)	107 (88.4)	95 (81.2)	88 (80.7)	12 (10.4)	11 (8.8)	10 (8.3)	14 (12.0)	10 (9.2)	4 (3.5)	6 (4.8)	4 (3.3)	8 (6.8)	9 (8.3)
UAC (cm)	97 (84.3)	112 (89.6)	101 (83.5)	99 (84.6)	88 (80.7)	11 (9.6)	8 (6.4)	19 (15.7)	10 (8.5)	13 (11.9)	7 (6.1)	6 (4.8)	1 (0.8)	8 (6.8)	8 (7.3)
BSF (mm)	85 (74.0)	95 (76)	99 (81.8)	102 (87.2)	88 (80.7)	22 (19.1)	28 (22.4)	17 (14.0)	9 (7.7)	13 (11.9)	8 (7.0)	2 (1.6)	5 (4.1)	6 (5.1)	8 (7.3)
TSF (mm)	97 (84.3)	108 (86.4)	106 (87.6)	97 (82.9)	89 (81.7)	10 (8.7)	13 (10.4)	12 (9.9)	12 (10.3)	11 (10.1)	8 (7.0)	4 (3.2)	3 (2.5)	8 (6.8)	9 (8.3)
SSSF (mm)	90 (78.3)	101 (80.8)	100 (82.6)	101 (86.3)	89 (81.7)	19 (16.5)	19 (15.2)	19 (15.7)	8 (6.8)	15 (13.8)	6 (5.2)	5 (4)	2 (1.7)	8 (6.8)	5 (4.6)
SISF (mm)	84 (73.0)	105 (84)	106 (87.6)	101 (86.3)	89 (81.7)	24 (20.9)	14 (11.2)	10 (8.3)	8 (6.8)	13 (11.9)	7 (6.1)	6 (4.8)	5 (4.1)	8 (6.8)	7 (6.4)

BMI=Body Mass Index; WC=Waist Circumference; WHR=Waist to hip ratio; UAC=Upper arm circumference; BSF=Biceps skinfold; TSF=Triceps skinfold; SSSF=Subscapular skinfold; SISF=Suprailiac skinfold; Figure in paranthesis indicates percentage (%)

Table 3: Distributions of optimal Sensitivity, Specificity and Likelihood ratios (LR) of anthropometric indices for common adiposity risk factors among pre-menarcheal Punjabi girls aged 8-12 years

Variables	Sensitivity					Specificity					LR				
	8 yrs	9 yrs	10 yrs	11 yrs	12 yrs	8 yrs	9 yrs	10 yrs	11 yrs	12 yrs	8 yrs	9 yrs	10 yrs	11 yrs	12 yrs
BMI(kg/m^2)	0.360	0.519	0.292	0.200	0.200	0.986	0.990	0.990	0.984	0.982	25.71	51.9	29.2	12.5	11.11
WC (cm)	0.480	0.593	0.292	0.150	0.200	0.986	0.959	0.990	0.984	0.982	34.28	14.46	29.2	12.5	11.11
WHR	0.400	0.519	0.333	0.150	0.200	0.986	0.969	0.990	0.984	0.982	28.57	16.74	33.3	12.5	11.11
UAC (mm)	0.440	0.630	0.375	0.150	0.300	0.986	0.918	0.990	0.984	0.964	31.43	7.68	37.5	9.37	8.33
BSF (mm)	0.560	0.630	0.458	0.250	0.350	0.857	0.867	0.948	0.984	0.946	3.92	4.74	8.81	15.62	6.48
TSF (mm)	0.440	0.519	0.333	0.150	0.200	0.986	0.969	0.990	0.984	0.982	31.43	16.74	33.3	9.37	11.11
SSSF (mm)	0.520	0.630	0.417	0.150	0.250	0.914	0.929	0.979	0.984	0.982	6.05	8.87	19.86	9.37	13.89
SISF (mm)	0.560	0.593	0.292	0.150	0.350	0.843	0.959	0.990	0.984	0.946	3.57	14.46	29.2	9.37	6.48

BMI=Body Mass Index; WC=Waist Circumference; WHR=Waist to hip ratio; UAC=Upper arm circumference; BSF=Biceps skinfold; TSF=Triceps skinfold; SSSF=Subscapular skinfold; SISF=Suprailiac skinfold

Table 4 display the value of AUCs (Area Under Curve) with 95% class intervals overlap and level of significance for anthropometric indices according to age group (8-12 years). Among 8 years, the areas (AUCs) of all anthropometric measurements have been found significant ($p<0.001$) with their respective cut-off values. However, the larger AUC (0.77; 95% CI: 0.652-0.889) have been found for waist circumference and triceps skinfold respectively. This indicates the accuracy of waist circumference and triceps skinfold in predicting adiposity in 8 years is fair enough (0.70-0.80 considered Fair classification). Among 9 years, the area (AUCs) of all the indicators have been found significant ($p<0.001$). The larger AUC (0.76; 95% CI: 0.634-0.892) have been found for upper arm circumference which indicates the accuracy of upper arm circumference in predicting adiposity among this age group. Among 10 years, again the areas of all the indicators have been found significant ($p<0.001$). The highest AUC (0.756; 95% CI: 0.635-0.878) has been found for upper arm circumference which is indicating the accuracy of upper arm circumference in predicting adiposity among this age group also. Among 11 years, again the areas of all the indicators have been found much lower than any of the previous age groups ($p<0.03$). Therefore, the areas of all indicators have been found below 0.7 which is indicating poor classification for predicting adiposity (Area= 0.60-0.70 considered Poor classification). Among 12 years, the almost same trend has been found as it was observed in 11 years of age group. Although all the areas have been shown significant, however, the ranges of areas are in between 0.60-0.70

which is indicating poor classification for all the indicators among this age group (Area= 0.60-0.70 considered Poor classification).

Table 4: Area under Receiver Operating Characteristic (ROC) curves for pre-menarcheal Punjabi girls aged 8-12 years.

	BMI (kg/ m²)	WC (cm)	WHR	UAC (cm)	BSF (mm)	TSF (mm)	SSSF (mm)	SISF (mm)
8 yrs								
Area (se)	0.766 (0.06)	0.770 (0.06)	0.768 (0.06)	0.760 (0.06)	0.749 (0.06)	0.770 (0.06)	0.752 (0.06)	0.747 (0.06)
P value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
95% CI	0.645-0.887	0.652-0.889	0.647-0.888	0.637-0.882	0.624-0.875	0.650-0.891	0.627-0.877	0.625-0.869
9 yrs								
Area (se)	0.753 (0.07)	0.749 (0.07)	0.749 (0.07)	0.763 (0.07)	0.754 (0.07)	0.756 (0.06)	0.756 (0.06)	0.748 (0.07)
P value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
95% CI	0.623-0.884	0.617-0.882	0.621-0.878	0.634-0.892	0.624-0.883	0.632-0.879	0.632-0.881	0.619-0.877
10 yrs								
Area (se)	0.750 (0.06)	0.746 (0.07)	0.752 (0.06)	0.756 (0.06)	0.732 (0.07)	0.753 (0.06)	0.731 (0.07)	0.740 (0.07)
P value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
95% CI	0.624-0.876	0.619-0.874	0.627-0.878	0.635-0.878	0.602-0.862	0.630-0.875	0.600-0.862	0.613-0.868
11 yrs								
Area (se)	0.656 (0.08)	0.651 (0.08)	0.659 (0.08)	0.658 (0.07)	0.659 (0.08)	0.658 (0.08)	0.660 (0.08)	0.667 (0.07)
P value	0.037	0.043	0.033	0.034	0.033	0.035	0.031	0.025
95% CI	0.508-0.804	0.501-0.801	0.510-0.808	0.515-0.801	0.510-0.807	0.509-0.806	0.514-0.807	0.524-0.810
12 yrs								
Area (se)	0.705 (0.07)	0.703 (0.07)	0.710 (0.70)	0.710 (0.07)	0.682 (0.08)	0.693 (0.07)	0.697 (0.07)	0.712 (0.07)
P value	0.007	0.007	0.006	0.005	0.016	0.011	0.009	0.005
95% CI	0.565-0.846	0.562-0.844	0.572-0.848	0.573-0.848	0.533-0.830	0.550-0.836	0.558-0.837	0.572-0.852

DISCUSSION

The major objective of the study is to detect excess adiposity among pre-menarcheal girls from 3 districts of Punjab. The study represents a multivariate model with Receiver Operating Characteristic (ROC) analysis which includes individual data with respect to different adiposity indicators such as body mass index, waist to hip ratio and skinfold thickness. Therefore, the present study can be used to derive biological cut-off values of different obesity indicators among pre-menarcheal Punjabi girls. The ROC analysis shows the ability of a classifier to rank positive instances to the negative instances. In the present analysis, the accuracy of ROC threshold score was measured greater than 0.5. Since the cut-off values for different obesity indicators differ in different countries, ethnic groups and races, therefore there is no global golden standard.[30-35] In present India, the transition in nutrition and life style with increasing popularity of fast foods, soft drinks, sedentary life style, lack of exercise, increased television watching and computer use are the common trends adopted by children today. These may be the causes of overweight seen in children of both rural and urban areas. According to a study by Unnithan and Syamakumari[36] among school going children in rural and urban areas of Kerala, it was interesting to note that among rural girls obesity seems to increase from 10 years (0.58 per cent) and reaches the peak at 12 years (5.66 per cent) and then gradually start decreasing as age advances and is lowest at 15 years with zero percent prevalence. When girls alone were considered, it was noted that out of a total of 889 rural girls and 880 urban girls the overweight prevalence was noted to be 11.92 and 20.90 percent respectively. And the obesity was found to be 2.25 percent in rural girls and 5.34 percent in urban girls. Studies reveal that in India, Kerala is not the only state facing the problem of overweight and obesity; it is growing in other states also.[19,37] Despite widespread concern about obesity which is the one of the significant culprit to develop cardiovascular diseases, the development of standard definitions of obesity for screening and intervention remains problematic.

Hence, it is important to develop simple and effective anthropometric indicators for screening obese subjects especially among young children. Therefore, the present study is an attempt to find out most distinctive index to be used as anthropometric indicators of excess adiposity for pre-menarcheal Punjabi girls within the age group of 8 to 12 years, based on ROC analysis. Results of the present study indicated different indicators to be used for different age groups. Waist circumference, triceps skinfold, waist to hip ratio and body mass index for 8 years; upper arm circumference and triceps skinfold for 9 years; upper arm circumference, triceps skinfold and waist to hip ratio for 10 years; suprailiac skinfold, subscapular skinfold and waist to hip ratio for 11 years ; suprailiac skinfold, waist to hip ratio and upper arm circumference for 12 years were the better indicators to assess excess adiposity among pre-menarcheal girl children in comparison of total eight indicators studied in the present study. The results of the present study as a whole indicated waist to hip ratio, triceps skinfold and upper arm circumference were the better indicators for screening in girl children of 8 to 12 years age group in comparison to other indicators, as it is reflected in the calculated area under ROC curve. However, many studies on children and adolescent have reported low senstivity and high specificity of all conventional indicators cut-off point in detecting adiposity .[9,11,12,14,38-40]

In the present study, the same trend has been found for all the age groups such as high specificity and low sensitivity. For higher area under ROC analysis, in the present study, a strong association between waist to hip ratio, triceps skinfold and upper arm circumference with adiposity has been found. However, body mass index is most widely used indicator of total adiposity but it cannot distinguish fat from muscle mass or peripheral central fat. Hence body mass index would not be a good indicator for the age group of 8 to 12 years. Therefore, our data is in line with results of other studies.[9,11,14,35,38-43] Hence it is interesting to note that the use of body mass index only could mislead in detecting the excess adiposity in pre-menarcheal girls. Waist to hip ratio and triceps skinfold are more appropriate to detect the excess adiposity. In reality, it is virtually impossible to achieve a high sensitivity and specificity simultaneously and one has to give more weight to the relative importance to sensitivity or specificity[11]. In fact, the use of 95th percentile of waist to hip ratio and triceps skinfold among premenarcheal Punjabi girls was associated with a high sensitivity and low specificity in the present study. Moreover, the World Health Organization[44] has stated that waist circumference/waist to hip ratio is the easiest and most efficient anthropometric index to be used for population based study to screen the excess adiposity.

CONCLUSION

ROC groups are very useful tool for visualizing and evaluating excess adiposity among pre-menarcheal girls. They are able to produce a richer measure of classifier performance than any other classification. Therefore, ROC graphs helps to promote better evaluation practices for screening the adiposity in the community. The present data provides first hand estimation of excess adiposity in pre-menarcheal Punjabi girls.

Limitation of the study: The present study has several strengths as well as some limitations. Following limitations were found in the present study. The main line of the study was that ROC was performed on a small sample size with respective of age and therefore, is not representative of total Punjabi population. Owing to this fact that different ethnic groups and culture heterogeneity is present in Punjab, it is imperative to study other ethnic groups to see the present trend of the result. Ethnic, cultural heterogeneity and socioeconomic status are not strictly identified which may lead to a spurious result. The present study is limited only to girl children, hence for baseline information to assess the usefulness of excess adiposity, male and female data should be included.

ACKNOWLEDGEMENTS

The authors are grateful to all subjects who participated in the study. We also would like to thanks to Mr Raman Kumar, Ms Sandeep Kaur, Ms Basanti Barna, Ms Manpreet Kaur and Neha Sudhir for their respective help for preparing the manuscript and collecting the data.

REFERENCES

1. Teixeira PJ, Sardinha LB, Going SB, Lohman TG. Total and regional fat and serum cardiovascular disease risk factors in lean and obese children and adolescents. Obes. Res. 2001; 9: 432-442.
2. Ribeiro J, Guerra A, Pinto A, Oliveria J, Duarte J, Mota J. Overweight and obesity in children and adolescents: relationship with blood pressure, physical activity. Ann. Hum. Biol. 2003; 30: 203-213.
3. Srinivasan SR, Bao W, Wattigeny WA, Berenson GS. Adolescent overweight is associated with adult overweight and related multiple cardiovascular risk factors: the Bogalusa Heart Study. Metabolism. 1996; 45: 235-240.
4. Bouchard C. The Obesity Epidemic: Introduction, Physical activity and Obesity. Human Kinetics Publishers, Champaign, IL; 2000. p. 3-20.
5. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for childhood overweight and obesity worldwide: international survey. BMJ 2000; 320**:** 1240-1243.
6. Mo-suwan L, Tongkumchum P, Purtpaiboon A. Determinants of overweight tracking from childhood to adolescence: a 5-year follow-up-study based on the Boyd Orr cohort. Am. J. Clin. Nutr. 1998; 67**:** 1111-1118.
7. Dietz WH. The obesity epidemic in young children. Reduce television viewing and promote playing. BMJ. 2001; 322**:** 313-314.
8. Gupta NK, Mueller WH, Chan W, Meninger J. Is obesity associated with poor sleep quality in adolescence? Am. J. Hum.Biol. 2002; 14**:** 762-768.
9. Sardinha LB, Going SB, Teixeira PJ, Lohman TG. Receiver operating characteristic analysis of body mass index, triceps skinfold thickness, and arm girth for obesity screening in children and adolescents. Am. J. Clin. Nutr. 1999; 70: 1090-1095.
10. Reilly JJ, Methven E, McDowell ZC, Hacking B, Alexandra D, Stewart L, Kelnar CJH. Health consequences of obesity. Arch. Dis. Child. 2003; 88: 748-752.
11. Bedogni G, Iughetti L, Ferrari M, Malavolti M, Poli M, Bernasconi S, Battisini N. Sensitivity and specificity of body mass index and skinfold thickness in detecting excess adiposity in children aged 8-12 years. Ann. Hum. Biol. 2003; 30**:** 132-139.
12. Gaskin PS, Walker SP. Obesity in a cohort of black Jamaican children as estimated by BMI and other indices of adiposity. Eur. J. Clin. Nutr. 2003; 57**:** 420-426.
13. Ghosh A, Bose K, Das AB, Chaudhuri. Association of food patterns, central obesity, easures and metabolic risk factors for coronary heart disease (CHD) in middle aged Bengalee Hindu men, Calcutta, India. Asia Pac. J. Clin. Nutr. 2003; 12**:** 166-171.
14. Ghosh A. Receiver operating characteristic (ROC) curve analysis in 5-10 year old Bengalee girls from Calcutta, India. Ann. Hum. Biol. 2004; 31: 364-369.
15. 15 World Health Organization, Consultation, Obesity: preventing and managing the global epidemic. WHO Technical Report Series, 2000; 894: 1-37.
16. Warriach HJ, Javed F, Farah-ul-Haq M, Khawaja FB, Saleem S. Prevalence of obesity in school going children of Karachi. PLoS ONE, 2009; 4: e 4816.
17. Ogden CL, Cynthia, Flegal K, et al., Prevalence and trends of overweight among US children and adolescents, 1999-2000. JAMA. 2002; 288: 1728-1732.
18. Bellizzi MC. Standard definition for childhood overweight and obesity. BMJ 2001; 321**:** 214-1216.
19. Kapil V, Singh P, Pathak P, Dwivedi SN, Bhasin S. Prevalence of obesity amongst affluent adolescent school children in Delhi. Ind. Pediat. 2002, 39: 449-452.
20. Sood A, Sundararaj P, Sharma S, Kurpad AV, Muthayya S. BMI and body fat percent in affluent adolescent girls in Bangalore city. Ind. Pediatr. 2007; 44: 587-591.
21. Badaruddoza, Gill K, Sandhu P. Factor analysis of anthropometric, physiometric and metabolic risk traits associated with cardiovascular diseases in North Indian Punjabi adults. J. Applied Sci. 2011; 11: 2843-2848.
22. Must A, Spandano J, Coakley EH, Field AE, Colditz G, Dietz WH. The disease burden associated with overweight and obesity. JAMA 1999; 282: 1523-1529.
23. Must A, Anderson SE. Effects of obesity on morbidity in children and adolescents. Nutr. Clin. Care. 2003; 6:4–11.
24. Snehlatha C, Vishwanathan V, Ramachandran A. Cutoff values for normal anthropometric variables in Asian-Indian adults. Diab. Care. 2003; 26: 1380-1384.
25. Singh IP, Bhasin MK. Anthropometry. Kamla Raj Enterprises, Delhi, 1968.
26. Weiner JS, Lourie JA. Practical Human Biology. Academic Press, London, 1981
27. Park SH, Goo JM, Jo C. Receiver operating characteristic (ROC) curve: practical review for radiologists. Korean J. Radiol. 2004; 5**:** 11-18.
28. Hanley J. The robustness of the "binormal" assumptions used in fitting ROC curves. Med. Decis. Making 1988; 8**:** 197-203.
29. Zweig MH, Campbell G. Receiver-operating characteristic (ROC) plots: a fundamental evaluation tool in clinical medicine. Clin. Chem. 1993; 39: 561-577.
30. Molanus A, Seidell JC. Selection of anthropometric indicators for classification of abdominal fatness- a critical review. Int. J. Obes. Relat. Metab. Disord. 1998; 22**:** 719-27.
31. Doll S, Paccaud F, Bovel P, Burnier M, Wietlisbach V. Body mass index, abdominal adiposity and blood pressure: consistency of their association across developing and developed countries. Int. J. Obes. Relat. Metab. Disord. 2002; 26**:** 48-57.
32. Mirmiran P, Esmaillzadeh A, Azizi F. Detection of cardiovascular risk factors by anthropometric measures in Tehranian adults: receiver operating characteristic (ROC) curve analysis. Eur. J. Clin. Nutr. 2004; 58**:** 1110-1118.
33. Zhu S, Heymsfield SB, Toyashima H, Wang Z, Pietobelli A, Heshka S. Race-ethnicity specific waist circumference cutoffs for identifying cardiovascular disease risk factors. Am. J. Clin. Nutr. 2005; 81: 409-415.
34. Lee CM, Huxley RR, Wildman RP, Woodward M. Indices of abdominal obesity are better discriminators of cardiovascular risk factors than BMI: a meta-analysis. J. Clin. Epidemiol. 2008; 61**:** 646-653.
35. Mellati AA, Mousavinasab SN, Sokhanvar S, Kazemi SAN, Esmailli MH, Dinmohamadi MH. Correlation of anthropometric indices with common cardiovascular risk factors in an urban adult population of Iran: data from Zanjan healthy heart study. Asia Pac. J. Clin. Nutr. 2009; 18**:** 217-225.
36. Unnithan AG, Syamakumari S. Prevalence of overweight, obesity and underweight among school going children in rural and urban areas of Thiruvananthapuram Educational District, Kerala State. The Internet J. Nutr. Wellness 2008; 6: 1-7.
37. Ramnath. The growing prevalence adolescent obesity in India. Ind.Pediatr. 2002; 157**:** 35-42.
38. Lazarus R, Baur L, Webb K, Blyth F. Body mass index in screening for adiposity in children and adolescents:

systematic evaluation using receiver operating characteristic curves. Am. J. Clin. Nutr. 1996; 63**:** 500-506.

39. Warner JT, Cowan FJ, Dunstan FDJ, Gregory JW. The validity of body mass index for the assessment of adiposity in children with disease states. Ann. Hum. Biol. 1997; 24: 209–215.
40. Sarria A, Moreno LA, Garcia LA, Fleta J, Morellan MP, Bueno M. The validity of body mass index, triceps skinfold and waist circumference in screening for adiposity in male children and adolescents. Acta Pediatrica. 2001; 90: 387-393
41. Onat A, Sansey V, Uysal O. Waist circumference and waist-to-hip ratio in Turkish adult: interrelation with other risk factors and association with cardiovascular disease. Int. J. Cardiol. 1999; 70**:** 43.
42. Oliveria CL, Veiga GV, Sichieri R. Anthropometric markers for cardiovascular disease risk factors among overweight adolescents. Nutr. Res. 2001, 21**:** 1335.
43. Ho SC, Chen YM, Woo JLF, Leung SSF, Lam TH, Janus ED. Association between simple anthropometric indices and cardiovascular risk factors. Int. J. Obes. 2001, 25**:** 1689-1697.
44. 44. World Health Organization. Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. WHO Technical Report Series, 1995; 854: 1–452.