ASSOCIATION OF ANTHROPOMETRIC INDEXES AND CARDIO-METABOLIC RISK FACTORS AMONG OBESE CHILDREN

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Abstract

BACKGROUND: Childhood obesity is associated with many cardio-metabolic risk factors, and different anthropometric measures have been considered to be associated with these risk factors. The aim of this study was to determine the best anthropometric index associated with cardio-metabolic risk factors among obese children and adolescents.

METHODS: This study was conducted by using data of the records of 2064 obese children and adolescents aged 6-18 years. Body mass index (BMI), waist circumference (WC), waist- to- hip ratio (WHR) and waist- to-stature ratio (WSR) were considered as anthropometric indexes. The cardio-metabolic risk factors were total cholesterol (TC), LDL-cholesterol (LDL-C),HDL-cholesterol (HDL-C), triglycerides (TG), fasting blood sugar (FBS), diastolic and systolic blood pressure (SBP and DBP).Data were analyzed with $SPSS_{16}$ using Receiver Operator Curve (ROC) and Pearson correlation analyses.

RESULTS: The prevalence of high LDL -C, TC, TG, FBS, SBP / DBP and low HDL - C was higher in boys than in girls. No single anthropometric index was found to be associated with risk factors in different sex and age groups. BMI, WC and WSR but not WHR had significant correlation with TC, LDL - C, TG, and FBS, whereas HDL - C had no significant correlation with anthropometric indexes.

CONCLUSION: Our results showed that in spite of all its limitations in differentiating fat mass and obesity pattern, BMI can be considered as a useful anthropometric index for predicting cardio-metabolic risk factors in obese children and adolescents. It may be clinically useful in pediatric population to routinely use WC and WSR -but not WHR- as a screening tool to identify at-risk children.

Keywords: Anthropometric measures, fat distribution, cardiovascular risk factors, children.

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Introduction

Obesity, a global epidemic concern, is becoming more noticed among children and adolescents in developed and developing countries.[1,2] In Iran, probably due to rapid westernization and lifestyle changes, the prevalence of overweight and obesity is increasing. The national prevalence of overweight and obesity in Iranian children aged 6-18 years is reported 8.82% and 4.5% respectively.[3] Some studies in adults and fewer in children showed associations between obesity with cardio-metabolic risk factors as dyslipidemia, high fasting blood sugar and high blood pressure.[4,5] Usually body mass index (BMI) is used to detect obesity, but it can not distinguish fat from muscle mass.[6] Waist circumferences (WC) and waist-to-hip ratio (WHR) are other indexes to measure obesity especially upper abdominal fat distribution or visceral obesity. The World Health Organization (WHO) recommended using WC and WHR to diagnose visceral fat distribution among adults.[7] Because of lack of universal definition on abdominal obesity for children, some researchers suggested a definition of waist-to-stature ratio more than 0.5 for the pediatric age group.[8] The

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associations of these anthropometric indexes with complications of obesity are documented in most previous studies in adults, but such information is limited among children.[6,9-11].
There is a large body of evidence that obesity-related diseases including its cardiovascular consequences begin in childhood.[6,12] Thus identifying high-risk children for targeted interventions is needed. In this study we assessed the correlations of some anthropometric indexes with cardio-metabolic complications in a large group of obese children and adolescents.

Materials and Methods

Data of this study was obtained from 2064 records of obese children and adolescents, aged 6-18 years, referred to the Pediatric Preventive Cardiology Department, Isfahan Cardiovascular Research Center (ICRC), affiliated to Isfahan University of Medical Sciences. The study was approved by the Ethics Committee of ICRC (NIH Code: FWA 0000t8578). Verbal assent was obtained from children and adolescents and informed written consent from their parents at entry to the study.

Only children and adolescents with simple obesity were studied, those cases with mental retardation, chronic medical problems and/or drug use, abnormal face or other signs compatible with syndromal obesity were not included in the study. All measurements of the individuals were made by the same trained general practitioners and nurses under the supervision of the same pediatrician. The age and birth date of subjects were recorded. Height (Ht) and weight (Wt) were measured twice to ± 0.2 cm and to ± 0.2 kg, respectively, with subjects being barefoot and lightly dressed; the averages of these measurements were recorded. Body mass index (BMI) was calculated by dividing weight (kilograms) by the height (meter) squared. Waist circumference (WC) was measured with a non-elastic tape at a point midway between the lower border of the rib cage and the iliac crest at the end of normal expiration. Hip circumference (HiC) was measured at the widest part of the hip at the level of the greater trochanter to the nearest half-centimeter.[13] Then, waist-to-hip ratio (WHR) and the waist-to-stature ratio (WSR) were computed by dividing the WC by the HiC and Ht, respectively. Blood pressure (BP) was measured using mercury sphygmomanometers after 5 min of rest in the sitting position. The subjects were seated with the heart, cuff, and zero-indicator on the manometer at the level of the observer's eye. All readings were taken in duplicate in the right arm. Appropriate size cuffs were used with cuff-width 40% of mid-arm circumference, and cuff bladders covering 80% to 100% of the arm circumference and approximately two thirds of the length of the upper arm without overlapping. The procedure was explained to the children and the cuff inflated and deflated once, the first BP measured was not used in the analysis of this study. The readings at the first and the fifth Korotkoff phase were taken as systolic and diastolic BP (SBP and DBP), respectively. The average of the two BP measurements was recorded and included in the analysis.[14] Data on fasting blood sugar (FBS) and lipid profile including total cholesterol (TC), low-density lipoprotein-cholesterol (LDL-C), high density lipoprotein-cholesterol (HDL-C) and triglycerides (TG) were registered.

The charts provided by the Centers for Disease Control and Prevention (CDC) were used for the classification of the BMI of children and adolescents.[15] Abnormal serum lipids were defined as a TC, LDL-C and or TG higher than the level corresponding to the age- and gender- specific 95th percentile, and/or HDL-C lower than age- and gender- specific 5th percentile.[16] FBS level equal or more than 100 mg/dl was considered as high.[17] Elevated BP was defined as the mean SBP and/or DBP above the 90th percentile for that age and gender after adjusting for weight and height.[14]

SPSS for Windows-version 16.0 (SPSS Inc., Chicago, IL) was used for data analysis. The correlation of anthropometric indexes and metabolic complication were determined by Pearson correlation test and Receiver Operator Characteristic (ROC) curves. First ROC curve analyses were used to calculate the area under curves (AUC) between each CVD risk factor and anthropometric index. Each value of an anthropometric index was used as a cutoff value to calculate its sensitivity and specificity in classifying a CVD risk factor. The ROC curve is a plot of the sensitivity against specificity for each cutoff value, and AUC is an indicator of how good the anthropometric indexes can distinguish a positive test outcome. AUC ranges from 0 to 1, with 0.5 (diagonal line) indicating that the anthropometric index has no predictive power and 1 indicating perfect power. After determining the best anthropometric index, the optimal cutoff value was denoted by the value that had the largest sum of sensitivity and specificity.[18-19] Because of the wide range of the age of the study population, we divided them in 3 age groups of 6-9.9, 10-13.9 and 14-18 years.

Results

The characteristics of the 2064 children and adolescents studied according to gender and age group are presented in Table 1. It shows that in general, the mean of BMI, HiC, LDL-C, HDL-C, TC, TG and FBS was higher in boys than in girls. HDL-C declined with increasing age.

Table 1. Characteristics of obese children and adolescents

	6-9.9 year	10 – 13.9 year	14 – 18 year	Total
Boys (Number)	390	445	94	929
Age	7.86(1.08)	11.30(1.08)	14.85(0.94)	10.22(2.49)*
BMI	23.08(3.92)	25.65(3.97)	29.05(4.25)	24.92(4.38)*
WC	76.33(8.28)	85.14(10.43)	95.06(11.45)	82.45(11.38)*
HC	83.53(7.79)	93.24(10.83)	102.90(11.29)	90.14(11.58)*
WHR	0.91(0.06)	0.92(0.06)	0.93(0.07)	0.92(0.06)
WSR	0.58(0.06)	0.57(0.06)	0.59(0.06)	0.58(0.06)
SBP	105.49(13.43)	109.76(13.16)	114.69(13.34)	108.45(13.61)*
DBP	63.66(8.68)	66.68(9.82)	68.01(9.50)	65.92(9.44)*
LDL-C	112.52(31.53)	116.55(33.04)	115.07(30.38)	114.72(32.17)
HDL-C	47.50(12.71)	45.35(10.94)	42.27(11.69)	45.93(11.87)*
TC	183.13(32.47)	188.89(34.91)	186.98(34.48)	186.30(33.94)
TG	115.36(65.33)	133.86(72.83)	155.04(84.94)	128.35(72.22)*
FBS	89.20(10.43)	89.10(12.19)	94.98(36.16)	89.77(16.04) *
Girls (Number)	545	467	123	1135
Age	7.77(1.07)	11.16(1.07)	15.15(1.25)	9.97(2.65) *
BMI	21.90(2.88)	25.06(3.38)	28.93(3.69)	23.96(3.92)*
WC	73.20(8.51)	81.97(9.78)	87.94(11.06)	78.24(10.74)*
HC	81.59(8.37)	90.88(10.82)	100.72(11.63)	87.31(11.68)*
WHR	0.90(0.06	0.90(0.06)	0.88(0.07)	0.90(0.06)*
WSR	0.55(0.06)	0.056(0.06)	0.57(0.06)	0.56(0.06)
SBP	102.78(13.72)	110.65(11.99)	113.11(12.11)	107.39(13.48)*
DBP	63.01(9.79)	66.86(8.94)	67.76(8.76)	65.23(9.52)*
LDL-C	110.92(29.99)	111.50(32.77)	113.54(33.09)	111.44(31.44)
HDL-C	46.21(12.06)	44.07(11.18)	43.19(9.66)	45.02(11.52) *
TC	181.84(32.80)	183.81(35.99)	182.84(39.54)	182.76(34.91)
TG	114.22(50.37)	137.65(68.35)	142.55(88.32)	126.96(64.31)*
FBS	87.30(11.79)	88.56(10.84)	86.53(9.88)	87.72(11.24)
Total (Number)	935	912	217	2064
Age	7.81(1.07)¶	11.23(1.08)	15.02(1.13) ¶	10.08(2.58) * ¶
BMI	22.39(3.40) ¶	25.35(3.69) ¶	28.98(3.93)	24.39(4.16)* ¶
WC	74.52(8.55) ¶	83.60(10.23) ¶	91.13(11.75)¶	80.19(11.24)* ¶
HC	82.41(8.18) ¶	92.10(10.88) ¶	101.70(11.49)	88.62(11.72)* ¶
WHR	0.90(0.06) ¶	0.91(0.06) ¶	0.90(0.08) ¶	0.91(0.06) ¶
WSR	0.56(0.06) ¶	0.57(0.06) ¶	0.58(0.06) ¶	0.57(0.06) ¶
SBP	103.99(13.65)¶	110.23(12.55)	113.81(12.65)	107.88(13.55)*
DBP	63.30(9.30)	66.77(9.36)	67.87(9.06)	65.36(9.48) *
LDL-C	111.57(30.61)	114.00(32.98)¶	114.19(31.89)	112.91(31.80) ¶
HDL-C	46.73(12.33)	44.70(11.07)	42.80(10.56)	45.43(44.68) *
TC	182.38(32.65)	186.30(35.54)¶	184.63(37.40)	184.35(34.51) ¶
TG	114.69(57.01)	135.80(70.55)	147.96(86.89)	127.59(67.96)*
FBS	88.09(11.28) ¶	88.83(11.52)	90.43(25.89)¶	88.66(13.68) ¶

* Significant at $P < 0.05$ between genders, ¶ Significant at $P < 0.01$ between age groups (by ANOVA and Tukey Post Hoc tests).
BMI: body mass index (kg/m^2), WC: waist circumference (cm), HiC: hipcircumference (cm), WHR: Waist-to-hip ratio, WSR: waist-to-stature ratio,SBP: systolic blood pressure (mm Hg), DBP: diastolic blood pressure (mmHg), TC: total cholesterol (mg/dl), LDL-C: low-density cholesterol (mg/dl), HDL-C: high-density cholesterol (mg/dl), TG: triglyceride (mg/dl), FBS: fasting blood sugar (mg/dl).

Similarly, the prevalence of some cardio-metabolic risk factors, as high TC, LDL-C, TG, FBS, SBP and DBP, as well as lower HDL-C was higher among boys than in girls (Table 2).

Table 3 presents the correlations of anthropometric indexes with biochemical measures. The correlations of WC, WHR, WSR, and BMI with FBS, TG, TC, and LDL-C were significant, whereas HDL-C had no significant correlation with anthropometric indexes.

Table 2: Prevalence of cardio-metabolic risk factors in obese children according to gender and age group

	Boys (n =929)	Girls (n =1135)	Total (n = 2064)
Prevalence (%)of high TC			
6 – 9.9 year	41.8	31.2	35.6*
10 – 13.9 year	32.2	26.3	29.2
14 – 18 year	42.9	23.5	31.9*
Total	37.3¶	28.4	32.4*¶
Prevalence (%)of high LDL-C			
6 – 9.9 year	27.2	15.7	20.3*
10 – 13.9 year	29.2	21.4	25.2*
14 – 18 year	32.9	20.4	25.7
Total	28.7	18.4	23*
Prevalence (%)of high HDL-C			
6 – 9.9 year	22.9	20.3	21.3
10 – 13.9 year	25.1	30.2	27.7
14 – 18 year	15.6	30.4	24.0*
Total	23.2	25.4¶	24.4¶
Prevalence (%)of high TG			
6 – 9.9 year	60.8	34	45.1*
10 – 13.9 year	56.5	53.7	55
14 – 18 year	52.2	47.5	49.5
Total	57.8	43.5¶	49.9*¶
Prevalence (%)of high FBS			
6 – 9.9 year	13.1	9.3	10.9
10 – 13.9 year	14.1	12.9	13.5
14 – 18 year	21.3	7.5	13.9*
Total	14.4	10.6	12.3*
Prevalence (%)of high SBP/DBP			
6 – 9.9 year	0.4	0.3	0.4
10 – 13.9 year	3	1.4	2.2
14 – 18 year	1.6	5	3.5
Total	1.7	1.3¶	1.5
Prevalence (%)of hyper lipidemia			
6 – 9.9 year	77	60.9	67.5*
10 – 13.9 year	73.8	71.1	72.4
14 – 18 year	75.8	64.7	69.5
Total	75.3	65.5¶	69.9*

*P < 0.05 between genders; ¶P < 0.05 between age groups

High BMI: body mass index ≥ 85th age and gender-specific percentile, high TC: total cholesterol ≥ 95th age and gender-specific percentile, high LDL-C: lowdensity cholesterol > 95th age and gender-specific percentile, low HDL-C: high-density cholesterol ≤ 5th age and gender-specific percentile, high TG: triglyceride ≥ 95th age and gender-specific percentile, high FBS: fasting blood sugar > 100 mg/dl, high SBP: systolic blood pressure ≥ 90th age and genderspecific percentile, high DBP: diastolic blood pressure ≥ 90th age and gender-specific percentile, high SBP/DBP: systolic/diastolic blood pressure ≥ 90th age and gender-specific percentile.

Table 3. Correlations of anthropometric indexes with blood biochemical measures of obese children and adolescents

		6 – 9.9 year				10 – 13.9 year				14 – 18 year				Total			
		BMI	WC	WHR	WSR	BMI	WC	WHR	WSR	BMI	WC	WHR	WSR	BMI	WC	WHR	WSR
	FBS	-0.02	0.127*	0.069	0.052	0.167**	0.179**	-0.012	0.166**	0.153	0.114	0.000	0.024	0.12**	0.16**	0.016	0.08*
	T.chol	0.048	0.06	0.035	0.054	0.237**	0.165**	0.128*	0.231**	0.043	0.021	0.16	-0.003	0.15**	0.12**	0.09*	0.13**
Boy	LDL	-0.004	-0.029	-0.001	-0.001	0.258**	0.139**	0.103	0.209**	-0.11	-0.16	-0.121	-0.167	0.12**	0.054	0.04	0.08
	HDL	-0.07	0.07	0.048	0.03	-0.017	0.004	-0.034	0.023	0.019	-0.11	0.16	-0.126	-0.09	-0.062	0.02	0.01
	TG	0.065	-0.002	-0.035	-0.064	0.053	0.126*	0.026	0.107	0.135	0.074	-0.183	0.014	0.13**	0.18**	-0.02	0.03
	FBS	0.086	0.075	-0.024	0.05	0.093	0.16*	0.012	0.084	0.11	0.19	0.197	0.229	0.08*	0.10**	0.023	0.07
	T.chol	0.017	-0.007	0.047	0.026	0.039	0.034	-0.014	0.107	0.119	0.09	0.184	0.275*	0.04	0.015	0.05	0.09*
Girl	LDL	0.019	-0.055	0.066	-0.002	0.017	-0.053	0.071	0.044	0.116	0.109	0.254*	0.259*	0.04	-0.027	0.10*	0.05
	HDL	-0.09*	-0.023	-0.083	-0.021	-0.017	-0.056	-0.063	0.017	-0.01	-0.18	0.051	-0.078	-0.10**	-0.09*	-0.05	-0.017
	TG	0.10*	0.136*	0.066	0.071	0.014	0.142*	0.065	0.166*	0.014	0.062	0.05	0.162	0.14**	0.20**	0.058	0.13**
	FBS	0.05	0.11**	0.027	0.05	0.14**	0.17**	0.001	0.13**	0.13	0.15	0.087	0.079				
	T.chol	0.035	0.027	0.046	0.045	0.15**	0.11**	0.066	0.18**	0.08	0.097	0.21**	0.17*				
Total	LDL	0.012	-0.037	0.038	0.005	0.15**	0.058	0.09*	0.14**	0.017	0.019	0.135	0.09				
	HDL	-0.07	0.023	-0.017	0.012	-0.014	-0.022	-0.045	0.023	0.007	-0.15	0.087	-0.11				
	TG	0.08*	0.063	0.009	-0.005	0.033	0.13**	0.042	0.13**	0.069	0.09	-0.023	0.10				

Significant at P<0.05, ** significant at P<0.01

BMI: body mass index (kg/m2), WC: waist circumference (cm), HiC: hipcircumference (cm), WHR: Waist-to-hip ratio, WSR: waist-to-stature ratio,SBP: systolic blood pressure (mm Hg), DBP: diastolic blood pressure (mmHg), TC: total cholesterol (mg/dl), LDL-C: low-density cholesterol (mg/dl), HDL-C: high-density cholesterol (mg/dl), TG: triglyceride (mg/dl), FBS: fasting blood sugar (mg/dl).

Figures 1 to 3 present ROC curves to determine the correlation of each cardiovascular risk factor with anthropometric indices which had perfect power according to gender and age groups.

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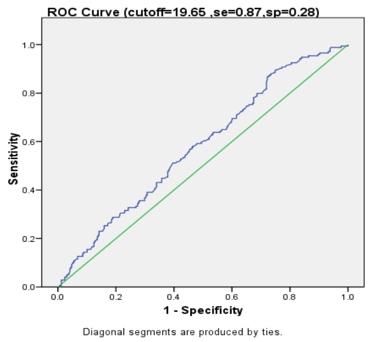
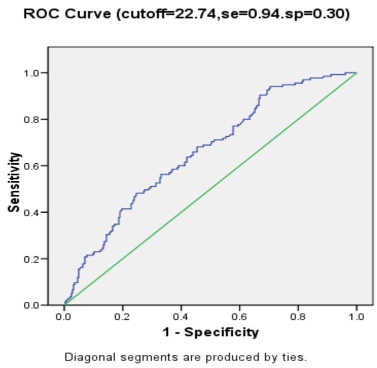
<tr><td>
</td><td>
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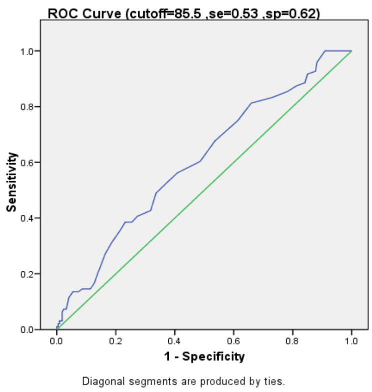
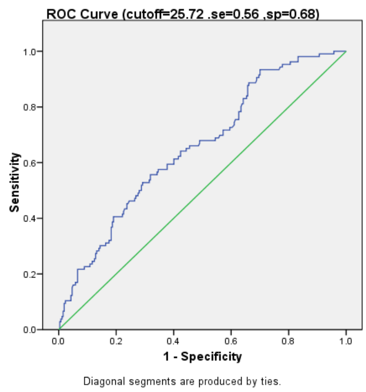
<tr><td>
</td><td>
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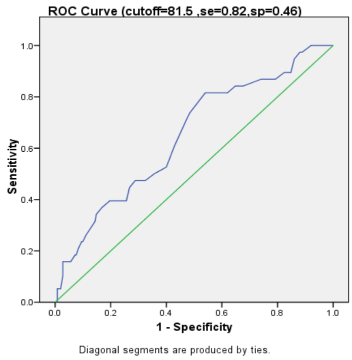
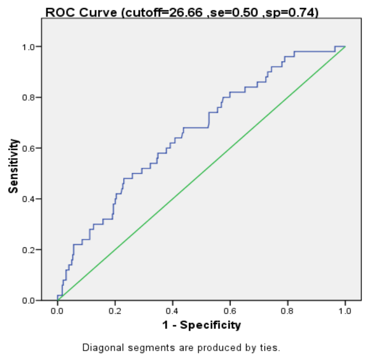
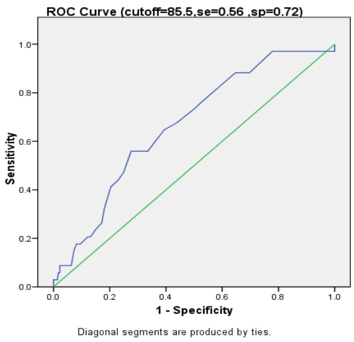
Fig. 1. ROC curve of lipid values and body mass index (BMI)
FBS: fasting blood sugar; TG: triglycerides; TC: total cholesterol.



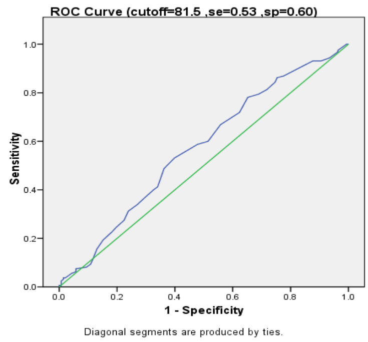
ROC curve of TC and WC in 10-14- year old boys



ROC curve of FBS and WC in 10-14- year old boys



ROC curve of FBS and WC in 10-14- year old girls



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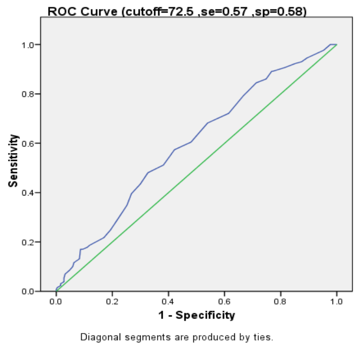
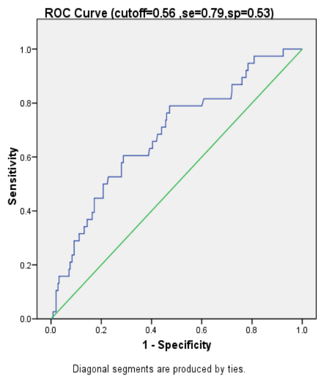
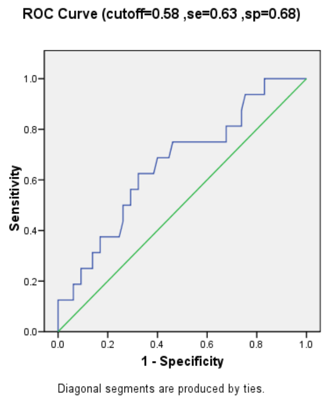


ROC curve of TG and WC in 6-10- yea old girls

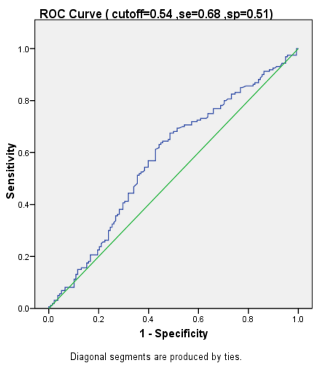
Fig 2. ROC curve of Lipid values and waist circumference (WC)
FBS: fasting blood sugar; TG: triglycerides; TC: total cholesterol.



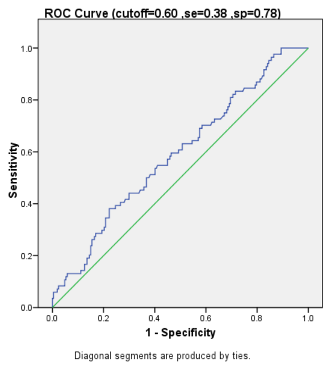
ROC curve of FBS and WSR in 10-14 years old boys



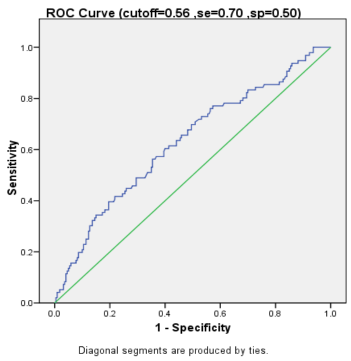
ROC curve of LDL-C and WSR in 14-18- year old girls



ROC curve of TG and WSR in 10-14 -year old girls



ROC curve of LDL-C and WHR in 10-14- year old boys



ROC curve of TC and WHR in 10-14- year old boys

Fig. 3. ROC curve of lipid values and with waist-to-stature ratio (WSR) and /or waist- to- hip (WHR) ratio
FBS: fasting blood sugar; TG: triglycerides; TC: total cholesterol.

Discussion

This study revealed that no single anthropometric index can be selected as the most appropriate one for predicting cardio-metabolic risk factors in children and adolescents. Furthermore it showed that such index would be different according to the gender and age group. Among 10-14 years old boys, WSR, BMI and WC were the best predictors of high TC and LDL-C. In general, BMI, WC and WSR were best predictors for high LDL-C, TC and TG in boys but there was no significant association between HDL-C and anthropometric indexes. Among 10-14- year- old girls, BMI, WSR and WC were the best predictors for high TG. WC for high TG and WSR for high LDL-C were the best predictors in 6-10 and 14-18 years old girls, respectively.

Our findings among overweight /obese children and adolescents are consistent with a previous national study in Iran that was conducted on a population-based sample of school students with different categories of BMI including underweight, normal weight, overweight and obese groups.[6] A study among a population-based study on 1037 children with a mean age of 11.4 years in Cyprus, WC and WSR followed by BMI were documented as the best predictors of cardiovascular risk factors.[20] In other study in Iran it has documented that BMI, WC and WHR were the most appropriate indexes in predicting dyslipidemia and high blood pressure among youths.[6]

However, our results were not consistent with some studies conducted among adults.[9-11] The study among Canadians revealed that WC and BMI correlate most closely with blood pressure and plasma lipids.[21] A population-based study showed that WC and WHR were the best predictors of dyslipidemia among Iranian adults.[8] In the current study as well as in our previous national study [6], WHR was a weak predictor of cardio-metabolic risk factors for children and adolescents; this might be because of the physiologic changes in fat deposition during growth and subsequent puberty. Our finding is consistent with a previous study which determined the diagnostic accuracy for detecting excess body fatness, measured by densitometry (air-displacement plethysmography), by different anthropometric indexes among Swedish adolescents by using ROC analyses. BMI and WC showed strong positive correlation with percent body fat in both genders, but the correlation was weak for WHR.[22]

In this study any significant correlation was not observed between HDL-C and anthropometric indexes. Two previous studies among children found significant correlation for these variables.[23-24] However they had lower sample size than our study, and one of them [23] was conducted among preschool children.

Some researchers have suggested that defining obesity by BMI has many disadvantages such as a lack of consensus on the cutoff for distinguishing overweight and obesity, and not presenting body fat distribution.[25] However, we found that BMI had good correlation with cardio-metabolic risk factors in both genders and in all age groups.

Study limitations &strengths: The main limitation of this study is its cross-sectional nature that would reduce the strengths of associations. Its main strength is its large sample size.

Conclusion

Our results showed that in spite of all its disadvantages, BMI is a useful anthropometric measure for predicting cardiovascular risk factors in children and adolescents. Contrary to adults, WHR had weak correlation with cardio-metabolic risk factors. However, it may be clinically useful in pediatric population to routinely measure WC as a screening tool to identify at-risk children. Given that WSR includes the variable of height, it would be useful for different ethnicities and age groups. Our findings should be confirmed by longitudinal studies.

Conflict of interest

None

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