OPEN ACCESS
Freely Available Online

JOURNAL OF BIOTECHNOLOGY AND BIOMEDICAL SCIENCE
ISSN NO: 2576-6694

Research Article

DOI : 10.1302/issn.2576-6694.jbbs-17-1850

Predictive Value of Some Central Obesity Anthropometric Indicators to Metabolic Risk Factors in Syrian Adolescents

Mahfouz Al-Bachir[1,]*, M Adel Bakir[2]

[1]Department of Radiation Technology, Atomic Energy Commission of Syria, Damascus, Syrian Arab Republic.

[2]Department of Radiation Medicine, Atomic Energy Commission of Syria, Damascus, Syrian Arab Republic.

Abstract

Obesity has become a serious health issue worldwide. There is much evidence that obesity among adolescents contributed to worsening blood biochemical profile that leads to development of many non-communicable diseases. Therefore, the aim of this study was to evaluate the predictive value of some central obesity anthropometric indicators to metabolic risk factors in the Syrian male adolescents. A cross-sectional study of a randomly selected sample of 2064 apparently healthy Syrian males' adolescents from Damascus city, Syria, aged 18 to 19 years was performed. Waist circumference (WC) and hip circumference (HC) were measured, and waist-to-hip ratio (WHpR) and waist-to-height ratio (WHtR) were calculated. Blood pressure (BP) was also measured. Serum fasting blood sugar (FBS), triglyceride (TG), low-density lipoprotein cholesterol (LDL-C), total cholesterol (Chol) were determined. The metabolic risk factors components were defined according to the national criterion. A receiver operating characteristics (ROC) curves were drawn to determine appropriate cut-off points of the WC, HC, WHpR and WHtR for defining the performance of these measurements as predictors of metabolic risk factors. The obtained data showed that BP and overall concentrations of TG, Chol and TG/HDL were significantly ($p<0.05$) increased with increasing WC, HC, WHpR and WHtR values. Based on ROC calculation for the measured anthropometric indicators and some metabolic syndrome (MetS) risk factors, the best WC HC, WHpR, WHtR cut-offs values were ranged between 73.15 - 79.90 cm, 93.75 - 101.10 cm, 0.80 - 0.81, and 0.43 and 0.47, respectively. These cut-off values were lower than the values recommended by the WHO. In conclusion: A significant association between the studied anthropometric indicators and the MetS components has been demonstrated. The best cut-offs of these indicators were defined. These cut-off values were lower than the values recommended by the WHO. Our results indicating that WC, WHpR and WHtR could be better predictors of MetS risk factors in Syrian adolescents.

Corresponding Author: Dr. Mahfouz Al-Bachir, Department of Radiation Technology, Atomic Energy Commission of Syria, Damascus, Syrian Arab Republic, P.O. Box 6091, E-mail: ascientific@aec.org.sy

Keywords: Anthropometric indicators, Obesity, Risk factor, Waist circumfeence, Syrian adolescents.

Running title: Obesity indicators and metabolic risk factors in adolescent

Received date: Oct 30, 2017 **Accepted date:** Dec 28, 2017 **Published date**: Jan 9, 2018

Editor: JUN WAN ,Department of Medical and Molecular Genetics, Indiana University School of Medicine Email: wjun2@wisc.edu

Introduction

Obesity has become a serious epidemic worldwide, estimated to be the fifth leading cause of death at global level, causing approximately 64 million deaths in 2015, 64% of those result from chronic illness unless urgent action is taken [1-5]. Moreover, the obesity in children and adolescents is also a major health issue, and its prevalence is increasing rapidly, mainly in developing countries. The International Obesity Task Force (IOTF) has stated recently that at least 500 million school children aged 5-17 years old are overweight or obese. Obesity is one of the Mets components which is a cluster of cardiovascular disease (CVD) risk factors including central obesity, diabetes, high serum cholesterol, high serum triglyceride, and high blood pressure [6]. It is well established that this syndrome leads to reduce the quality of life and premature death [7]. The association between the MetS and adolescents obesity has been reported in many published data [3]. Obesity plays an essential role in the MetS through worsening of blood biochemical profile that leads the development of many non-communicable diseases such as CVD, diabetes, and stroke. There is an increasing evidence that the obesity and MetS among adolescents is associated with a number of health adverse consequences in adulthood such as type 2 diabetes mellitus and CAD [8-10]. The atherosclerosis process starts at an early age is linked to obesity and other components of MetS in childhood [11]. The association between childhood obesity and cardio-metabolic risk factors, i.e. abdominal obesity, glucose disorders, dyslipidaemia and hypertension in adolescents have been evaluated through many studies and substantial links have been shown [12]. Also, studies have demonstrated that increased body mass index (BMI) in adolescents has a significant link with type 2 diabetes mellitus and CVD incidence in adulthood [8, 13].

There are other studies indicated that central obesity (abdominal obesity) in which fat accumulates in the abdominal cavity and around the viscera is associated with a much higher risk for CVD, stroke, and type-2 diabetes mellitus in adolescents than just excess accumulation of fat in the subcutaneous tissue [14-21]. This type of fat is more metabolically active than subcutaneous fat and has been shown to have more adverse health consequences than overall obesity. Evidences suggest the importance of measuring central obesity besides overall obesity for the evaluation of health risks in the first decades of life [22]. In addition, recent published data indicated that the percentage of patients who presented with Mets risk factors has almost doubled in the last ten years [23]. Therefore, it is highly urgent to develop valid and simple methods for identifying individuals with Mets mainly at a younger ages. Central obesity is measured by various anthropometrics methods such as WC, WHpR and WHtR, which is the main component of the MetS [19, 24-25]. The relative risk for CVD and the (MetS) increases significantly with increasing the central obesity, defined as WC larger than 102 cm for men and 88 cm for women [26]. Also, several studies have proposed the use of WHpR for central obesity measurement indicated value ranging from 0.85 to 0.95 in men, and from 0.80 to 1.18 in women [27]. Recently, WHtR has been proposed as another simple index to measure the central obesity and a cut off value ≥0.5 was suggested for defining the obesity in children and adults [28]. This cut-off value was found to be strongly associated with cardiovascular risk factor [29]. It must be highlighted that the association between central obesity as accessed by the WC, and arterial blood pressure, has been largely reported in the adult population. However, until now, the predictive value of WC related to blood pressure levels has not been suggested for children and adolescents [30]. Meanwhile, prediction values for anthropometrics indicators were also not determined in the Syrian adolescents. Therefore, the aim of this study was to evaluate the predictive value of some central obesity anthropometric indicators such as the WC, HC, WHpR and WHtR, to MetS risk factors including BP, Chol, LDL, HDL, TG, and FBS.

Materials and Methods

Participants

A cross-sectional study consisted of sample of 2064 healthy adolescents aged 18 to 19 years from Damascus city, Syria, was performed. All participants underwent a brief clinical examination to exclude those with clinical history of chronic diseases including cardiovascular, renal, hepatic, or any abnormalities might affect body composition. Subjects were asked to abstain completely from consuming food and drink 12 hours before visiting the testing field. All anthropometry measurements and blood sampling were completed during a single visit to the testing area. The study protocol was approved by the scientific research and the ethical committee of the Atomic Energy Commission of Syria (AECS). Each participant provided informed consent prior to participation after a detailed explanation of the study protocol. This study was performed in accordance with guidelines prescribed by Helsinki declaration of the world medical association

Anthropometry Measures

Anthropometric measurements include weight; height, HC, and WC. Body weight was measured to the nearest 0.1 kg using a calibrated electronic scale (Seca, Model: 7671321004; Germany; D=0.05 to 0.1 kg) and height was measured to the nearest 0.1 cm using a well-mounted stadiometer (Seca, Model: 225 1721009; Germany). Subjects were measured barefoot in light underwear. WC was measured in midway between the lateral lower rib margin and the iliac crest. HC was measured at the levels of the trochanters, through the pubic symphysis. Measurements were performed to the nearest millimeter using a non-stretchable tape over the unclothed body. Three measurements were made and the mean expressed in cm used for analysis. WHpR was obtained by dividing WC by HC. WHtR was obtained by dividing WC by Ht.

Biochemical and Clinical Tests

The main metabolic syndrome risk factors and some clinical important parameters were included in this study**.** Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured in adolescents in a sitting position after rest using a mercury sphygmomanometer. Blood samples were collected from all participating adolescents after 12 hours of overnight fasting. Serum was separated by centrifugation. Serum glucose (GOD-PAP method, Human Co.), cholesterol (Chol), low density lipoprotein cholesterol (LDL-C), high density lipoprotein cholesterol (HDL-C), (CHOD-PAP method, Human Co.), triglycerides (TG) (GPO-PAP method, Human Co.), fasting blood sugar (FBS, Human Co.) were determined using commercial kits. Hematocrit (Ht), and hemoglobin (Hb) were measured using routine methods.

Biochemical, Clinical, and Overweight/obesity Cut-off Values

The normal range for each studied metabolic component was defined using national criterion as follows: SBP (90–135 mm Hg); DBP (60–89 mm Hg); FBS (65-110 mg/dl); TG (25-200 mg/dl); Chol (50-200 mg/dl); HDL-C (40-75 mg/dl); LDL-C (less than 155 mg/dl); Ht (40-45 mg/dl); Hb (13-18 g/dl) [18]. TG/HDL-C (less than 3) [19]. Overweight and obesity were defined as a participant with WC ≥94 cm and ≥102 cm as overweight and obese, respectively [20]. The participants with WHpR ≥0.90 or WHtR ratio of ≥0.5were classified as obese [20].

Statistical Analysis

Statistical analyses were performed using the Statistical Package for Social Science SPSS for windows (Version 17.0.1, 2001, SPSS Inc., Chicago, USA). Continuous variables were expressed as mean±SD, whereas categorical variables were represented by frequency and percentage. Student's T test in SPSS was performed to determine the statistical significance. The P value of less than 0.05 was considered statistically. Receiver operating characteristics (ROC) curve was drawn to determine appropriate cut-off points of the WC, WHpR, WHtR for defining overweight and obesity. The area under curve (AUC) with 95% confidence interval (CI) values provided an indication of the performance of WC, WHpR, WHtR as predictors of health risk [21, 22].

Results

The mean values (mean ±SD) of measured MetS components for 2064 adolescents participated in the current study were as follows: SBP (123.43± 14.55 mm Hg), DBP (74.40± 10.72mm Hg), FBS (89.49± 8.53 mg/100 ml), TG (91.84± 44.06mg/100 ml), Chol (136.36± 33.04mg/100 ml), HDL-C (57.11± 5.63mg/100 ml), LDL-C (62.04± 29.34mg/100 ml), and TG/HDL-C (1.61±0.78). The mean values of MetS risk factors in the studied group of Syrian adolescents by WC categories classified according to the weight status values are illustrated in table 1. As shown in this table DBP, Chol, TG, and TG/HDL-C were significantly ($p<0.05$) higher in overweight and obese subjects in comparison to normal weight subjects. Meanwhile, SBP and FBS were significantly ($p<0.05$) higher in obese subjects than in normal participants, and LDL-C was significantly higher

Table 1. The mean of MetS risk factors in the studied group of Syrian adolescents by WC categories classified according to the weight status.

Characteristics	Normal (N=1938) <94 cm	Overweight (N=87) 94-102 cm	Obesity (N=39) >102 cm	LSD 5%
SBP (mm Hg)	123.1±14.6[a]	125.8±14.0 [ab]	128.3±13.6 [b]	14.55
DBP (mm Hg)	74.2±10.7 [a]	77.4±11.4 [bc]	80.0±9.1 [c]	10.72
FBS (mg/100ml)	89.3±8.5 [a]	91.0±7.8 [ab]	93.8±7.4 [b]	8.53
TG (mg/100ml)	89.6±41.5 [a]	118.9±55.9 [b]	142.1±77.7 [c]	44.06
Chol (mg/100ml)	135.5±32.7 [a]	151.4±36.7 [c]	145.8±31.4 [bc]	33.04
HDL-C (mg/100ml)	57.1±5.6 [a]	56.8±5.6 [a]	57.2±5.7 [a]	5.63
LDL -C (mg/100ml)	61.6±29.3 [a]	71.7±29.5 [b]	61.7±30.4 [ab]	29.34
TG/HDL	1.57±0.13 [a]	2.13±1.07 [b]	2.50±1.40 [c]	0.78

(MetS): metabolic syndrome; (WC): Waist circumference; (N): number of subjects; (LSD): lower slandered deviation; (SBP): Systolic blood pressure; (DBP) diastolic blood pressure; (FBS): fasting blood sugar; (TG): triglycerides; (Chol): cholesterol; (HDL-C): high density lipoprotein cholesterol; (LDL-C): low density lipoprotein cholesterol;.

Table 2. The MetS risk factors in the studied group of Syrian adolescents by WHpR and WHtR categories classified according to the weight status.

Characteristics	WHpR			WHtR		
	Normal (N=1973) <0.9	Obesity (N=91) >0.9	P value	Normal (N=1784) <0.5	Obesity (N=280) >0.5	P value
SBP (mm Hg)	123.1±14.5[a]	127.6±14.5[b]	0.004	122.8±14.5[a]	126.7±14.3[b]	0.000
DBP (mm Hg)	74.3±10.7[a]	77.8±10.6[b]	0.002	73.9±10.6[a]	77.8±10.9[b]	0.000
FBS (mg/100ml)	89.5±8.5[a]	90.8±8.9[a]	0.242	89.3±8.5[a]	91.0±8.3[b]	0.002
TG (mg/100ml)	90.5±42.4[a]	120.8±64.7[b]	0.000	88.5±40.9[a]	112.9±56.4[b]	0.000
Chol (mg/100ml)	136.0±32.9[a]	143.2±34.6[b]	0.043	134.6±32.2[a]	147.8±35.8[b]	0.000
HDL-C (mg/100ml)	57.1±5.7[a]	58.0±5.2[a]	0.124	57.1±5.7[a]	57.4±5.6[a]	0.400
LDL-C (mg/100ml)	62.0±29.4[a]	62.8±28.1[a]	0.805	61.0±29.0[a]	68.5±30.9[b]	0.000
TG/HDL	1.60±0.75[a]	2.12±1.36[b]	0.000	1.56±0.72[a]	1.98±1.02[b]	0.000

(MetS): metabolic syndrome; (WHpR) waist-to-hip ratio; (WHtR) waist-to-height ratio; (N): number of subjects; (SBP): Systolic blood pressure; (DBP) diastolic blood pressure; (FBS): fasting blood sugar; (TG): triglycerides; (Chol): cholesterol; (HDL-C): high density lipoprotein cholesterol; (LDL-C): low density lipoprotein cholesterol.

in overweight subjects than in normal once. However, there was no significant differences in HDL-C value among the three studied groups (normal, overweight and obese). WHtR (≥0.5) was found to be significantly ($p<0.05$) prevalent among participants with high BP (systolic and diastolic), FBG, TG, Chol, LDL-C and TG/HDL-C. Also, the participants with high WHpR (≥0.9) were shown significantly ($p<0.05$) higher BP (systolic and diastolic), TG, Chol, and TG/HDL-C. The results are shown in table 2.

ROC curves analysis of the WC, HC, WHpR and WHtR were performed for all studied MetS components. Regarding WC, AUC predicting metabolic abnormalities ranged between 0.37 and 0.69 and it was statistically significant ($p>0.05$) for SBP, DBP, Chol, TG, LDL-C and TG/HDL-C. The best WC cut-offs for the studied group were 73.15, 75.25, 79.90, 75.40, 75.40 and 76.83 cm for SBP, DBP, TG, Chol, LDL-C and TG/HDL-C, respectively, as illustrated in table 3. AUC predicting metabolic abnormalities of HC ranged between 0.37 and 0.71 and it was statistically significant ($p>0.05$) for DBP, TG, Chol, LDL-C and TG/HDL-C. The best HC cut-offs for the studied group were 93.75, 94.75, 94.90, 95.95, and 94.75 cm for DBP, TG, Chol, LDL-C and TG/HDL-C, respectively, as indicated in table 4. AUC predicting metabolic abnormalities of WHpR ranged between 0.43 and 0.65 and it was statistically significant ($p>0.05$) for SBP, DBP, Chol, TG, and TG/HDL-C. The best WHpR cut-offs for the studied group were 0.80, 0.81, 0.81, 0.81 and 0.81 for SBP, DBP, TG, Chol and TG/HDL-C, respectively, as shown in table 5.AUC predicting metabolic abnormalities of WHtR ranged between 0.44 and 0.70 and it was statistically significant ($p>0.05$) for SBP, DBP, Chol, TG, LDL-C and TG/HDL-C. The best WC cut-offs for the studied group were 0.43, 0.44, 0.46, 0.46, 046 and 0.45 for SBP, DBP, TG, Chol, LDL-C and TG/HDL-C, respectively, as in table 6.

Discussion

In this cross-sectional study of Syrian adolescents aged 18-19 years a significantly higher values of anthropometric parameters of central obesity as measured by WC (≥94 cm), WHpR (≥0.9), and WHtR (≥0.5) were reported in those with high values of the Mets components. These values tended to increase as WC increased. These findings are in agreement with other studies which showed a strong correlation of WC with most of Mets components. The association of WC with a number of cardio metabolic risk factors, reported in this study and in a number of previous reports, encourage to propose to use this parameter as a simple method of identifying those who are at risk of developing CVD and type II diabetes mellitus [35]. Also, many studies have investigated the usefulness of WC as an alternative index for central obesity as that increase in WC predicts the risk for insulin resistance, adverse lipid profiles, high blood pressure and metabolic syndromein adolescents [36, 37]. While Burgos et al. [30] demonstrated a moderate correlation among these variables. However, Sarni et al. [38] did not find correlation between WC and SBP or DBP in sample of 65 preschoolers of low socioeconomic status. In the present study the data, also, suggested a relative predictive value of WHpR, however, this value was not as high as WC and WHtR. In some published data the WHpR has been demonstrated a reliable predictor of health related parameters in adults, however, this ratio index was poor proxy central fatness in children and adolescents [39]. Peterson et al. [40] reported that WHpR was found to be a significant predictor of HDL-C, total cholesterol/high-density lipoprotein cholesterol (TC/HDL-C) ratio, and TG.

In the current criteria for metabolic syndrome, we used a common cut-off value for the WC for Syrian adolescents. When using this cut-off threshold, it raises a problem in that the visceral fat area (VFA) for the adolescents is underestimated. Therefore, different cut-off values for the WC, WHpR and WHtR according to the age should be considered. The results of this study suggest that all used anthropometric indicators (WC, HC, WHpR and WHtR) are associated with one or more metabolic risk factors in adolescents. ROC curve analysis indicated that, among the indicators used to predict the presence of metabolic syndrome, DBP, TG, Chol, LDL-C, and TG/HDL-C have showed a great area under the ROC curve, but the TG was the index that showed the greatest area under the ROC curve. Based on the sensitivity, specificity, and ROC calculation, we found that WC, HC, WHpR and WHtR have a good accuracy for identifying adolescents with some metabolic risks including DBP, TG, Chol, LDL-C, and TG/HDL-C. This data suggest that, the best WC, HC, WHpR, WHtR cut-offs ranged between 73.15-79.90 cm,

Table 3. Sensitivity, specificity and AUC of cutoff values of WC in prediction of MetS risk factors for Syrian adolescents.

Characteristics	**Criteria**	**WC Cutoff value**	**Sensitivity %**	**Specificity %**	**Area under the curve (AUC)**	**P value**
SBP (mm Hg)	> 135 mm Hg	73.15	54.3	51.3	0.53	0.017
DBP (mm Hg)	> 89 mm Hg	75.25	53.8	62.5	0.60	0.000
FBS (mg/100ml)	> 89 mg/100ml	75.75	45.8	61.3	0.48	0.738
TG (mg/100ml)	> 200 mg/100ml	79.90	56.9	76.1	0.70	0.000
Chol (mg/100ml)	> 200 mg/100ml	75.40	64.0	61.6	0.66	0.000
HDL-C (mg/100ml)	< 75 mg/100ml	78.05	30.0	71.3	0.37	0.143
LDL-C (mg/100ml)	< 155 mg/100ml	75.40	80.0	60.9	0.69	0.038
TG/HDL-C	> 3 mg/100ml	76.85	57.9	66.7	0.66	0.000

(AUC): area under curve; (WC): Waist circumference; (MetS): metabolic syndrome; (SBP): Systolic blood pressure; (DBP) diastolic blood pressure; (FBS): fasting blood sugar; (TG): triglycerides; (Chol): cholesterol; (HDL-C): high density lipoprotein cholesterol; (LDL-C): low density lipoprotein cholesterol

Table 4. Sensitivity, specificity and AUC of cutoff values of HC in prediction of MetS risk factors for Syrian adolescents.

Characteristics	**Criteria**	**HC Cutoff value**	**Sensitivity %**	**Specificity %**	**Area under the curve (AUC)**	**P value**
SBP (mm Hg)	> 135 mm Hg	94.05	44.9	59.9	0.52	0.333
DBP (mm Hg)	> 89 mm Hg	93.75	60.3	56.9	0.61	0.000
FBS (mg/100ml)	> 89 mg/100ml	94.90	37.5	60.3	0.44	0.312
TG (mg/100ml)	> 200 mg/100ml	94.75	65.5	61.1	0.68	0.000
Chol (mg/100ml)	> 200 mg/100ml	94.90	65.3	61.3	0.67	0.000
HDL-C (mg/100ml)	< 75 mg/100ml	101.10	30.0	83.0	0.37	0.167
LDL-C (mg/100ml)	< 155 mg/100ml	95.95	70.0	64.6	0.71	0.025
TG/HDL-C	> 3 mg/100ml	94.75	60.5	61.5	0.64	0.000

(AUC): area under curve; (HC): hip circumference; (MetS): metabolic syndrome; (SBP): Systolic blood pressure; (DBP) diastolic blood pressure; (FBS): fasting blood sugar; (TG): triglycerides; (Chol) cholesterol; (HDL-C): high density lipoprotein cholesterol; (LDL-C): low density lipoprotein cholesterol

Table 5. Sensitivity, specificity and AUC of cutoff values of WHpR in prediction of MetS risk factors for Syrian adolescents.

Characteristics	Criteria	WHpR Cutoff value	Sensitivity %	Specificity %	Area under the curve (AUC)	P value
SBP (mm Hg)	> 135 mm Hg	0.80	57.7	50.7	0.55	0.002
DBP (mm Hg)	> 89 mm Hg	0.81	51.1	59.7	0.57	0.001
FBS (mg/100ml)	> 89 mg/100ml	0.81	54.2	58.4	0.54	0.553
TG (mg/100ml)	> 200 mg/100ml	0.81	60.3	58.8	0.66	0.000
Chol (mg/100ml)	> 200 mg/100ml	0.81	57.3	58.9	0.61	0.001
HDL-C (mg/100ml)	< 75 mg/100ml	0.77	90.0	24.1	0.43	0.461
LDL-C (mg/100ml)	< 155 mg/100ml	0.81	70.0	58.4	0.61	0.231
TG/HDL-C	> 3 mg/100ml	0.81	63.2	59.5	0.65	0.000

(AUC): area under curve; (WHpR) waist-to-hip ratio; (MetS): metabolic syndrome; (SBP): Systolic blood pressure; (DBP) diastolic blood pressure; (FBS): fasting blood sugar; (TG): triglycerides; (Chol): cholesterol; (HDL-C): high density lipoprotein cholesterol; (LDL-C): low density lipoprotein cholesterol.

Table 6. Sensitivity, specificity and AUC of cutoff values of WHtR in prediction of MetS risk factors for Syrian adolescents.

Characteristics	Criteria	WHtR Cutoff value	Sensitivity %	Specificity %	Area under the curve (AUC)	P value
SBP (mm Hg)	> 135 mm Hg	0.43	58.3	47.7	0.54	0.017
DBP (mm Hg)	> 89 mm Hg	0.44	57.3	57.0	0.60	0.000
FBS (mg/100ml)	> 89 mg/100ml	0.46	41.7	68.5	0.47	0.664
TG (mg/100ml)	> 200 mg/100ml	0.46	69.0	63.3	0.70	0.000
Chol (mg/100ml)	> 200 mg/100ml	0.46	64.0	63.4	0.68	0.000
HDL-C (mg/100ml)	< 75 mg/100ml	0.47	30.0	75.0	0.44	0.499
LDL-C (mg/100ml)	< 155 mg/100ml	0.46	60.0	68.5	0.68	0.047
TG/HDL-C	> 3 mg/100ml	0.45	63.2	63.9	0.68	0.000

(AUC): area under curve; (WHtR) waist-to-height ratio; (MetS): metabolic syndrome; (SBP): Systolic blood pressure; (DBP) diastolic blood pressure; (FBS): fasting blood sugar; (TG): triglycerides; (Chol): cholesterol; (HDL-C): high density lipoprotein cholesterol; (LDL-C): low density lipoprotein cholesterol

93.75-101.10 cm, 0.80-0.81 cm, and 0.43 cm and 0.47 cm, respectively. These cut-off values of were lower than the current definitions recommended by the WHO [32].

However, the absolute risk currently determined by the multiple risk factors associated with body fat and its distribution may well reflect the phase of disease transition in a population. Hence, the thresholds for risk associated with WC or WHpR may vary with time. These considerations make it difficult to specify cut-off points on the basis of ethnicity [16,41]. Cut-off points chosen vary considerably between countries; also, the variation is greater for WC than for WHpR. The cut-off points appear to be chosen based on disease risk and on hard outcomes such as mortality [42].

Males who have WC greater than 102 cm are considered to be at increased risk for CVD. This cut-off point was derived from a regression curve that identified the WC value associated with a body mass index (BMI) ≥30 kg/m^2 in primarily Caucasian men [42]. The current recommendation for central adiposity as recommended by WHO WC ≥94 cm and a value WHpR is ranging from 0.85 to 0.95 in men [42]. However, data indicate a lower WHpR cut-off point for Asians; for example, WC values of 85 cm, and WHpR values of 0.90, respectively [43]. Studies in populations of the Middle East Region have provided WC and WHpR cut-off points similar to those suggested for Europeans [42]. In Japan, a WC of 80 cm has been established as one of various cutoff points for childhood obesity disease [44].

Conclusion

Our findings indicate that central obesity as determined by the main anthropometric indicators WC, WHpR and WHtR have a significant association with the major components of MetS suggesting that visceral fat accessed by these indicators can be good predictors of this syndrome in Syrian adolescents. Based on ROC calculation for WC, HC, WHpR, and WHtR and some metabolic risk factors, the best cut-offs of these parameters were defined in this study. These cut-off values were lower than the values recommended by the WHO.

Conflict of Interests

The authors declare that there is no conflict of interest regarding publication of this paper.

Author Contribution

The authors equally contributed to this paper.

Abbreviations

AECS Atomic Energy Commission of Syria, CHD cardiovascular heart diseases, DBP diastolic blood pressure, SBP systolic blood pressure, FBS fasting blood sugar, Chol cholesterol, HDL-C high density lipoprotein cholesterol, LDL-C low density lipoprotein cholesterol, SBP systolic blood pressure, SD standard deviation, SPSS Statistical Package for Social Science, TG triglycerides.

Acknowledgements

The authors wish to express their deep appreciation to the Director General of AECS Prof. I. Othman. This study was supported by the International Atomic Energy Agency under the Technical Research Contract No. SYR/6/012 is gratefully acknowledged.

References

1. World Health Organization (WHO). Obesity and Overweight. Fact sheet N0311. Updated March 2013. [Online]. [Cited 2013]. Available from URL: http://www.who.int/mediacentre/factsheets/fs311/en/.
2. Victora, C.G., Adair, L., Fall, C., et al. (2008). Maternal and child under nutrition: Consequences for adult health and human capital. Lancet, 371, 340-357.
3. Haslam, D.W., James, W.P.T. (2005). "Obesity". Seminar. Lancet, 366, 1197-1209
4. Baratta, R., Degano, C., Leonardi, D., Vigneri, R., Frittitta, L. (2006). "High prevalence of overweight and obesity in 11-15-year-old children from Sicily". Nutr Metab Cardiovasc Diseases, 16, 249-255.
5. Swallen, K.C., Reither, E.N., Haas, S.A., Meier, A.M. (2005). "Overweight, obesity, and health-related quality of life among adolescents: the National Longitudinal Study of Adolescents". Health Pediatr., 115, 340-347.
6. Liu, P., Ma, F., Lou, H., et al. (2013). The utility of fat mass index vs. body mass index and percentage of body fat in the screening of metabolic syndrome. PMC Public Health. 2013; doi: 10.1186/1471-2458-13-629. 10.1186/1471-2458-13-629.
7. Asfaw, A. (2008). The effects of obesity on doctor- diagnosed chronic diseases in Africa:

empirical results from Senegal and South Africa. J. Public Health Policy, 27(3), 250-264.

8. Morrison, J.A., Friedman, L.A., Wang, P., Glueck, C.J. (2008). Metabolic syndrome in childhood predicts adult metabolic syndrome and type 2 diabetes mellitus 25 to 30 years later. J Pediatr., 152, 201-6.
9. Biro, F.M., Wien, M. (2010). Childhood obesity and adult morbidities. Am J Clin Nutr., 91, 1499-1505.
10. Nadeau, K.J., Maahs, D.M., Daniels, S.R., Eckel, R.H. (2011). Childhood obesity and cardiovascular disease: links and prevention strategies. Nat Rev Cardio., 8, 513-525.
11. Berenson, G.S., Srinivasan, S.R., Bao, W., Newman, W.P., Tracy, R.E., Wattigney, W.A. (1998). Association between multiple cardiovascular risk factors and atherosclerosis in children and young adults. N Engl J Med., 338, 1650-1656.
12. Garnett, S.P., Baure, L.A., Srinivasan, Lee, J.W., Cowell, C.T. (2007). Body mass index and waist circumference in midchildhood and adverse cardiovascular disease risk clustering in adolescence. Am J Clin Nutr., 86, 549-555.
13. Agirbasli, M., Agaoglu, N.B., Ergonul, O., Yagmur, I., Aydogar, H., Oneri, T., Ozturk, O. (2011). Comparison of anthropometric indices in predicting metabolic syndrome components in children. Metab Syndr Relat Disord., 9, 453-459.
14. Lurbe, E., Alvarez, V., Redon, J. (2001). Obesity, body fat distribution, and ambulatory blood pressure in children and adolescents. J. Clin. Hypertens., 3, 362-367.
15. Zhang, C., Rexrode, K.M., van Dam, R, M. et al., (2008). Abdominal obesity and the risk of all-cause, cardiovascular, and cancer mortality: sixteen years of fellow-up in US women". Circulation, 117, 1658-1667.
16. Zhu, S., Wang, Z., Heshka, S., Heo, M., Faith, M.S., Heymsfield, S.B. (2002). Waist circumference and obesity-associated risk factors among whites in the third National Health and Nutrition Examination Survey; clinical action thresholds. Am. J. Nutr., 76, 743-749.
17. Sawa, S.C., Tornaritis, M., Sawa, M.E... et al., (2000). Waist circumference and waist-to-height ratio are better predictors of cardiovascular disease risk factors children than body mass index. Int. J. Obes. Relat. Metab. Disord., 24, 1453-1458.
18. Singh, S., Virend, K., Somers, M.D., Mathew, M., Clark, Vickers, K., Donald, D., Hensrud, M.D., Korenfeld, Y., Lopez-Jimenez, F., Robester, M.N. (2010). Physician diagnosis of overweight status predicts attempted and successful weight loss in patients with cardiovascular disease and central obesity. Am. Heart. J., 160, 934-942.
19. Rastogi, P., Pinto, D.S., Pai, M.R., Kanchan, T. (2012). An autopsy study of coronary atherosclerosis and relation to anthropometric measurments/indices of overweight and obesity in men. J. Forensic. Leg. Med., 19, 12-17.
20. Rizzo, A.C.B., Goldberg, T.B.L., Silva, C.C., Kurokawa, C.S., Nunes, H.R.C. (2013). Metabolic syndrome risk factors in overweight, obese, and extremely obese Brazilian adolescents. Nutr. J., 2013; doi: 10.1186/1475-2891-12-19.
21. Ryan, J.M., Crowley, V.E., Hensey, O., McGahey, A., Gorml, J. (2014). Waist circumference provides an indication of numerous cardio metabolic risk factors in adults with cerebral palsy". Arch Phys Med Rehabil. 2014 Apr 14. pii: S0003-9993(14)00280-9. doi: 10.1016/j.apmr.2014.03.029. [Epub ahead of print].
22. Lee, S., Bacha, F., Gungor, N., Arslanian, S. (2008). Comparison of different definitions of pediatric metabolic syndrome: relation to abdominal adiposity, insulin resistance, adiponection, and inflammatory biomarkers. J. pediatr., 152, 177-184.
23. Franco OH, Massaro JM, Civil J, et al. (2009). Trajectories of entering the metabolic syndrome: The Framingham Herat study. Circulation, 120, 1943 –50.
24. Morimoto, A., Nishimura, R., Kanda, A., Sano, H., Matsudaira, T., Miyashita, Y, Shirasawa, T., Takahashi, E., Kawaguchi, T., Tajima, N. (2007). Waist circumference estimation from BMI in Japanese children. Diabetes Res. Clin. Pr., 75, 96-98.
25. De Koning, L., Merchant, A.T., Pogue, J., Anand, S.S. (2007). Waist circumference and waist-to-hip ratio as predictors of cardiovascular events: meta-

regression analysis of prospective studies. Eur. Heart. J., 28, 850-856.

26. Teixeira, da Silva MdeL., Renofio Martins, J., Midori Shiroma, G., Ortolani, M.C., Mika Horie, L. (2008). Nutritional recommendation alone does not change the obesity profile of health professionals. Nutr. Hosp., 23, 429-432.
27. Okosun, I.S., Liao, Y., Rotimi, C.N., Choi, S., Cooper, R.S. (2000). Predictive values of waist circumference for dyslipidemia, type 2 diabetes and hypertension in overweight White, Black and Hispanic American adults. J. Clin. Epidemiol., 53, 401-408.
28. Ashwell, M.A., Hsieh, S.D. (2005). Six reasons why the waist-to-height ratio is rapid and effective global indicator for the health risks of obesity and how its use could simplify the international public health usage on obesity. Int. J. Food Sci. Nutr., 56, 303-307.
29. Freedman, D.S., Kahn, H.S., Mei, Z., Strawn, L.M.G., Dietz, W.H., Srinivarsan, S.R. (2007). Relation of body mass index and waist-to-height ratio to cardiovascular risk factors in children and adolescents: the Bogalusa heart study. Am. J. Clin. Nutr. 86, 33-40.
30. Burgos, M.S., Burgos, L.T., Camargo, M.D., Franke, S.I.R., Para, D., Vargas da Silva, A.M., Borges, T.S., Todendi, P.F., Reckziegel, M.B., Reuter, C.P. (2013). Relationship between anthropometric measures and cardiovascular risk factors in children and adolescents. Arq Bras Cardiol. 2013; vol.101 no.4 São Paulo Oct. 2013 Epub Aug 27, 2013.http://dx.doi.org/10.5935/abc.20130169.
31. Marotta, T., Russo, B.F., Ferrara, A. (2010). Triglyceride-to-HDL-cholestrol ratio and metabolic syndrome as contributors to cardiovascular risk in overweight patients. Obes., 18, 1608-1613.
32. World Health Organization (WHO). (2011). Waist circumference and waist-hip ratio: Report of WHO Expert consultation, 2011; Geneva, 8-11 December 2008.
33. Singh, L.C.S.P., Sikri, S.L.C.G., Garg, L.C.M.K. (2008). Body Mass Index and Obesity Tailoring "cut-off" for an Asian Indian Male Population. M.J.A.F.I., 64, 350-353.
34. Kesavachandran, N.C., Bihari, B., Mathur, N. (2012). The normal range of body mass index with high body fat percentage among male residents of Lucknow city in north India. Indian J. Med. Res., 135, 72-77.
35. Ryan, J.M., Crowley, V.E., Hensey, O., McGahey, A., Golml, J. (2014). Waist circumference provides an indication of numerous cardio metabolic risk factors in adults with cerebral palsy". Arch Phys Med Rehabil. 2014 Apr 14. pii: S0003-9993(14)00280-9. doi: 10.1016/j.apmr.2014.03.029. [Epub ahead of print].
36. Watts, K., Bell, L.M., Byrne, S.M., Jones, T.W., Davies, E.A. (2008). Waist circumference predicts cardio-metabolic risk in young Australian children. J. Pediatr. Child. Health., 44, 709-715.
37. Genovesi, S., Antolini, L., Giussani, M., Pieruzzi, F., Galbiati, S., Valsecchi, M.G., et al., (2008). Usefulness of waist circumference for the identification of childhood hypertension. J. Hypertens., 26, 1563-1570.
38. Sarni, R.S., Souza, F.I., Schoeps, D.O., Catherino, P., Oliveira, M.C., Pessoti, C.E., et al., (2006). Relationship between waist circumference and nutritional status, lipid profile and blood pressure in low socioeconomic level pre-school children. Arq. Bras. Cardiol. 87, 153-158.
39. Taylor, R.W., Jones, I.E., Williams, S.M., Goulding, A. (2000). Evaluation of waist circumference, waist-to-hip ratio, and the conicity index as screening tools for high trunk fat mass, as measured by dual-energy X-ray absorptiometry, in children aged 3-19 y. Am. J. Clin., Nutr., 72, 490-495.
40. Peterson, M.D., Haapala, H.J., Hurvitz, E.A. (2012). "Predictors of cardiometabolic risk among adults with cerebral palsy". Arch Phys Med Rehabil., 93, 816-821.
41. Zhu, S., Heymsfield, S.B., Toyoshima, H., Wang, Z., Pietrobelli, A., Heshka, S. (2005). "Race- ethnicity-specific circumference cut-offs for identifying cardiovascular disease risk factors". Am J Clin Nutr., 81, 904-915.
42. Wildman, R.P., Gu, D., Reynolds, K., Duan, X., He, J. (2004). "Appropriate body mass index and waist circumference cutoffs for categorization of

overweight and central adiposity among Chinese adults". Am J Clin Nutr., 80, 1129 -1136.

43. Seidell. J.C. (2010). Waist circumference and waist/hip ratio in relation to all-cause mortality, cancer and sleep apnea. Eur. J. Clini. Nutr., 64, 35-41.
44. Asayama, K., Ozeki, T., Sugihara, S., et al., (2003). Criteria for medical intervention in obese children: a new definition of "obesity disease" in Japanese children. Pediatr. Int., 45, 642-646.