Anthropometric Indices for the Prediction of Metabolic Syndrome and its Features, among Children and Adolescents

Deepika Bahl1*, Kalyani Singh1, Manisha Sabharwal1 and Monika Arora2

1Department of Foods and Nutrition, Lady Irwin College, Sikandara Road New Delhi 110001, India; bahl.deepa@gmail.com
2Health Promotion and Tobacco Control and Adjunct Assistant Professor Public Health Foundation of India, Delhi, India

Abstract

Metabolic syndrome refers to cluster of cardiovascular diseases risk factors, not only seen in adults but in children and adolescents too. Though in children and adolescents its prevalence is not as high as among adults, the existence even in low percentage poses greater economic burden and hurdle to national development. Identification of subjects with this syndrome can only be done if data on anthropometry (height, weight or waist circumference, blood pressure) and biochemical (fasting blood glucose, High density lipoprotein triglycerides) is available. But biochemical estimation especially in children and adolescents is difficult due to its poor acceptance because of its invasive nature. Thus, it leads to non recognition of this syndrome. Therefore there is a need to build up a strategy where in these young age group are not ignored by health professionals. Based on review, prevalence is higher among overweight and obese subjects in comparison to normal weight. Overweight and obese subjects should be screened through the use of anthropometric measurements such as waist circumference, body mass index, waist to height ratio and neck circumference. Screened subjects then should be subjected to invasive techniques for confirmation of syndrome. This process of prediction will be cost effective and also the high risk subject will not be ignored. Anthropometric indices have different sensitivity and specificity to predict metabolic syndrome at a younger age but the index was found to be significantly correlated with Metabolic syndrome is waist circumference.

Keywords: Adolescents, CVD Risk Factors Children, Metabolic Syndrome

1. Introduction

In the field of medical science, Metabolic Syndrome (MS) has become one of the most frequently used terms1. Its presence in an individual illustrates the constellation of Cardiovascular Disease (CVD) risk factors like hypertension, obesity, elevated triglycerides, low HDL cholesterol (altered lipid levels) and glucose intolerance2. Various international organizations and expert groups such as the World Health Organization (WHO), European Group for the study of Insulin Resistance (EGIR), National Cholesterol Education Program Adult Treatment Panel (NCEP ATP), American Association of Clinical Endocrinology (AACE), International Diabetes Federation (IDF) and American Heart Association/National Heart, Lung, and Blood Institute, have attempted to define MS1. From all the definitions, modified NCEP ATP III (2003) and IDF definitions (2007) (Table 1) have a universal appeal as the components in it could be easily measured in any small clinic or laboratory in a developing country at a very low cost3.
1.1 Metabolic Syndrome and Economic Aspect

Occurrence of MS is increasing at a striking rate worldwide with a simultaneous increase in childhood obesity among both genders and all racial, ethnic and socioeconomic groups. Presence of MS in an adult is associated with a 2-fold higher risk of CVD and a 5-fold higher risk of diabetes and has a 30%–40% probability of developing diabetes and/or CVD within 20 years as compared to subjects without MS. Progression of MS to this disease has an impact on the overall growth and economy of a country both in direct and indirect ways. Direct cost includes impact on families, healthcare sectors including consultation, investigations, medications, management, hospitalization, treating complications, transportation and time utilized for care in case of nonmedical expenses. Indirect cost includes impact on society and government, which are related to productivity costs, work days lost, low productivity, disability payment, social security and depression. In 2005, loss in national income from heart disease, stroke and diabetes was estimated for various countries; for instance 18 billion dollars in China, 9 billion dollars in India, and 2.7 billion dollars in Brazil and the estimates for the same countries for year 2015 are 3 to 7 times higher than year 2005.

Recently, estimations for economic impact of Non Communicable Disease (NCD) on India have been made for year 2012–2030. Total losses associated with five major NCD (diabetes, CVD, respiratory disease, cancer and mental health) was USD 2.6 trillion. But the CVD was estimated to cause maximum loss i.e. USD 1.21 trillion. Thus emphasizing it requires constant attention.

1.2 Metabolic Syndrome No More an Adult Problem

There are many studies done globally with adults as subjects and high prevalence of MS has been reported but recent trends are changing; MS is now being seen in children and adolescents too. These trends were visible in developed countries before developing countries (Table 2). Among developed countries higher prevalence has been seen in overweight and obese children and adolescents in comparison to those of normal weight. Among developing countries, similar trends have been seen. Although from developing countries maximum studies have been reported from India. As per Indian data, prevalence is much higher in overweight and obese children and adolescents, though it may exist in adolescent with normal weight. Though this situation may be hidden but it is a significant problem.

1.3 Prediction of Metabolic Syndrome

Keeping in view the increasing prevalence of MS around the globe and the economic loss contributed by the progression of MS to deadly diseases (CVD and diabetes),
Table 2. Prevalence of Metabolic Syndrome among children and adolescents in developed and developing countries

<table>
<thead>
<tr>
<th>Author , year and country</th>
<th>Age , sample Size</th>
<th>Definition of metabolic syndrome</th>
<th>Prevalence according to criteria used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developing Countries</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Rizzo et al.21 Brazil</td>
<td>10-16 yrs</td>
<td>IDF</td>
<td>18.3%</td>
</tr>
<tr>
<td>2. Wang et al.22 China</td>
<td>6-18 yrs</td>
<td>IDF</td>
<td>Obese: 14.3%, Overweight: 3.7%</td>
</tr>
<tr>
<td></td>
<td>3373 children and adolescents</td>
<td>Modified NCEP5</td>
<td>Obese: 32.3%, Overweight: 8.4%</td>
</tr>
<tr>
<td>3. Li et al.23 China</td>
<td>15-19 yrs</td>
<td>De Ferranti</td>
<td>Overall: 3.7%</td>
</tr>
<tr>
<td>4. Singh et al.15 India</td>
<td>12-17 yrs</td>
<td>Modified NCEP ATP 5</td>
<td>Overall: 4.2%</td>
</tr>
<tr>
<td>5. Gupta et al.24 India</td>
<td>15-18 yrs</td>
<td>Modified NCEP 5 with triglyceride≥150 mg/dl</td>
<td>0.0% in male and 0.2% in females</td>
</tr>
<tr>
<td>6. Kapil and Kaur14 India</td>
<td>6-18 yrs</td>
<td>IDF with blood pressure ≥95th percentile for age and sex , 2007</td>
<td>6.5% (males 6.9% and females 5.9%)</td>
</tr>
<tr>
<td>7. Yatheesha et al.25 India</td>
<td>81 children &amp; adolescents</td>
<td>Modified NCEP 5</td>
<td>25.9%</td>
</tr>
<tr>
<td>8. Saha et al.26 India</td>
<td>6-11 yrs 49 obese children</td>
<td>De Ferranti, et al, 2004</td>
<td>14.3%</td>
</tr>
<tr>
<td>9. Singh et al.27 India</td>
<td>10-18 yrs</td>
<td>Modified NCEP 5</td>
<td>Overall: 2.67% Males 3.8% females 1.62%</td>
</tr>
<tr>
<td>10. Andrabi et al.28 India</td>
<td>8-18 yrs</td>
<td>Modified NCEP 5</td>
<td>Overall: 3.8% Males 3.9% females 3.8%</td>
</tr>
<tr>
<td>11. Malonda and Tangkilisani29 Indonesia</td>
<td>10-14 yrs 30 obese &amp; 30 overweight</td>
<td>Modified NCEP 5</td>
<td>13 obese and 3 overweight subjects had MS</td>
</tr>
<tr>
<td>12. Esmaillzadeh et al.30 Iran</td>
<td>3,036</td>
<td>Modified NCEP 5</td>
<td>Overall: 10.1% Males:10.3% Females:9.9%</td>
</tr>
<tr>
<td>13. Kelishadi et al.31 Iran</td>
<td>6-18 yrs</td>
<td>Modified ATP III criteria (8), but fasting blood glucose 100 mg/dl</td>
<td>Overall: 14.1% Males:15% Females:11%</td>
</tr>
<tr>
<td>14. Barzin et al.32 Iran</td>
<td>11-18 yrs</td>
<td>IDF</td>
<td>Males:25.5% Females:1.8%</td>
</tr>
<tr>
<td>15. Wee et al.33 Malaysia</td>
<td>9-12 yrs 402 children (193-Normal weight, 209 overweight / obese)</td>
<td>IDF</td>
<td>5.3% of the overweight/obese children</td>
</tr>
<tr>
<td>16. Cook et al.35 United States</td>
<td>12-19 yrs</td>
<td>Modified NCEP</td>
<td>Overall: 4.2% Males:6.1% Females:2.1%</td>
</tr>
</tbody>
</table>
need of the hour is predicting and identifying individuals with MS at early ages (children and adolescent) to reduce the burden of CVD and diabetes. The main contributor for increasing prevalence of MS is, growing obesity among children and adolescents. Thus there is a need to identify these high risk subjects. Screening by use of biochemical testing is expensive, invasive and time consuming because testing involves detection of multiple risk factors. However identifying subjects by anthropometry to delineate high risk subjects and further evaluation by blood testing and diagnosing MS is appropriate. Anthropometry had been selected as a measure of prediction due to its universal appeal, it is less expensive, less invasive, easy to use, more success rates, accurate to assess size, composition and proportions of human body and in managing long term cardiovascular risk factors. Anthropometric measures frequently used to assess overweight and obesity status among children and adolescents are Body Mass Index (BMI), Waist Circumference (WC), waist to height ratio and neck circumference and these measures are associated with MS and its features in children and adolescents.

### 1.3.1 Waist Circumference

It is an index of abdominal obesity. Various organisations and the expert groups have attempted to give information on waist measurement protocol. As per WHO, measurement should be made at the approximate midpoint.

<table>
<thead>
<tr>
<th>Developed countries</th>
<th>Age</th>
<th>Study Population</th>
<th>Risk Assessment</th>
<th>Risk of overweight</th>
<th>Overweight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cruz et al.41</td>
<td>8-19 yrs</td>
<td>126 overweight children</td>
<td>Modified NCEP</td>
<td>6.8%</td>
<td>28.7%</td>
</tr>
<tr>
<td>Schumacher et al.35</td>
<td>8-10 yrs</td>
<td>214 overweight &amp; obese</td>
<td>Modified NCEP</td>
<td>Overall: 5.6%</td>
<td></td>
</tr>
<tr>
<td>Mehairi et al.36</td>
<td>12-18 yrs</td>
<td>1018 adolescents</td>
<td>IDF</td>
<td>Males:21%</td>
<td></td>
</tr>
<tr>
<td>Sen et al.37</td>
<td>2-19 yrs</td>
<td>352 obese children and adolescents</td>
<td>Modified NCEP</td>
<td>Overall: 41.8%</td>
<td></td>
</tr>
<tr>
<td>Moran et al.38</td>
<td>10-18 yrs</td>
<td>965 children and adolescents</td>
<td>ATP III, AACE, WHO, EGIR</td>
<td>Overweight:22.3%</td>
<td></td>
</tr>
<tr>
<td>Ryu et al.39</td>
<td>12-13 yrs</td>
<td>1393 adolescents</td>
<td>Modified NCEP</td>
<td>Overall: 5.5%</td>
<td></td>
</tr>
<tr>
<td>Kim et al.40</td>
<td>South Korean adolescents in 1998 and 2001; numbers of subjects aged 12–19 years were 1,317 in 1998 and 848 in 2001</td>
<td>Modified NCEP</td>
<td>1998: 6.8%</td>
<td>2001:9.2%</td>
<td></td>
</tr>
<tr>
<td>Seo et al.41</td>
<td>10-19 yrs</td>
<td>3431 children and adolescents</td>
<td>Modified NCEP</td>
<td>Overall: 5.3%</td>
<td></td>
</tr>
<tr>
<td>You and Son42</td>
<td>12-18 yrs</td>
<td>606 adolescents</td>
<td>Modified NCEP</td>
<td>Overall:13.0%</td>
<td>15.4% boys 10.0% girls</td>
</tr>
</tbody>
</table>

between the lower margin of the last palpable rib and the top of the iliac crest. The United States (US) National Institutes of Health (NIH) protocol and the protocol used in the US National Health and Nutrition Examination Survey (NHANES) III indicated that it should be measured at the top of the iliac crest. The NIH also provided a protocol for the measurement of waist circumference for the Multi-Ethnic Study of Atherosclerosis (MESA) study. This protocol indicates that the waist measurement should be made at the level of the umbilicus or navel. However, published reports indicate that measurements of waist circumference made at the level of the umbilicus may underestimate the true waist circumference.

Once the prescribed protocol is followed, this measurement appears to be simple, effective and easier to obtain because of a single measurement and poses minimal participant burden because clothing needs to be removed only from the abdominal area and thus fits best in identifying children who are at risk of developing MS. NCEP-ATP-III and IDF established increased WC as the basic criterion in the diagnosis of MS as the most effective anthropometric index. Data from 22125 school children in Taiwan was studied and the evidence from the results made the author to conclude WC is the best predictor of metabolic abnormalities. To know the association, anthropometric measures (WC, hip circumference, arm girth, triceps skin fold, scapular thickness, wrist circumference and BMI) with metabolic abnormality by partial correlation were estimated from logistic regression. Higher the value of this statistical measure, higher was the degree of association between the two variables. The partial correlation was highest for WC (partial R² = 10.69%), followed by BMI (partial R² = 9.80%) and WC explained higher variance than BMI for the metabolic derangements. Study with biracial samples (African-American youths and Caucasian youths), proved WC as an independent correlate of daytime and night-time BP and dyslipidemia. Significant results were seen for WC correlation with Blood Pressure (BP) and Triglycerides (TG), High Density Lipoproteins (HDL), TG/HDL and Very-Low-Density Lipoprotein (VLDL) even after controlling for BMI percentiles; however BMI percentile did not correlate with BP and lipids after accounting for WC independent of race. Similar results have been reported where WC has performed better than BMI in predicting abnormal cardio metabolic phenotypes among adolescents and supports the inclusion of WC in definition of MS. Another study concluded that MS factors clustered significantly higher in children with WC greater than 90 percentile than in children with the waist circumference less than 90 percentile. The result of study indicated that it was not predictive of MS whereas WC and BMI had shown the strongest association to predict MS. According to Lee et al. where the WC threshold values/ percentiles for 938 adolescents (10–18 yrs) had been calculated for predicting metabolic risk factors. WC derived from ROC analysis were 55th and 32th percentiles in males and females 10–15 years of age, and 73cm and 76cm in males and females 16–18 years of age, respectively. At these threshold percentiles/values for WC, 71–100% of adolescents were correctly classified as having two or more MS components (sensitivity) and 37–87% of them were correctly classified as not having two or more MS components (specificity). Data from Bogulas Heart involving 3000 children and adolescents of age 5–17 years analysed by Freedman et al concluded that WC may help in identifying children likely to have adverse concentration of lipids and insulin. Similar strong correlation was seen in a cohort study involving Australian Aboriginal and Italian children of age 3–11 years. However the result was not similar, when the researcher included adolescents and young adults of age 14–25 years from New Delhi and came to the conclusion WC was inferior to BMI and subscapular skin fold thickness in identifying hyperinsulinemia in males and the presence of three or more risk factors of MS. Gender difference has been seen in studies reported, amongst Taiwan male adolescents. WC was most significant variable associated with MS in males but not among female adolescents.

WC has not only been used with adolescents for predicting MS but also with primary school children. A study was conducted by Hirschler et al. with 5,103 children age 4–13yrs and findings were summarized as waist circumference value of 75th percentile could be the right and practical tool to identify young children at risk for future type 2 diabetes and cardiovascular disease. Certain precautions which need to be considered while measuring WC to maintain its specificity and sensitivity are appropriate anatomical placement of the measuring tape, its tightness and the type of tape used, the subject's posture, phase of respiration, abdominal tension, stomach contents and clothing.

**1.3.2 Body Mass Index**

It represents weight to height ratio indicating body weight in relation to height. It is widely used tool for...
the assessment of overweight and obesity among adults and children but its use in children and adolescents is still a controversial issue because it seems to give a limited insight of degree of excess body fat. For correct interpretation, BMI measures have to be expressed as z scores or percentiles relative to age and sex, as BMI is strongly related to growth and maturation. Although BMI is being routinely measured at all ages because of its prognostic significance, it is not an accurate measure of adiposity.

BMI assessment is recommended by the American Academy of Pediatrics for the screening of adiposity related diseases. As per American Diabetic association for early screening in children, BMI > 85th percentile should be considered. Evidence from the cross-sectional study with 1,194 children of 9 years age which compared several anthropometric indices; triceps Skin-Fold Thickness (SFT), waist circumference, hip circumference, waist-to-hip ratio, body mass index and waist-to-height ratio and their association with metabolic syndrome. The study findings suggested age- and sex-specific cut off points of BMI could be used to screen MS. Similar results were seen in a study by Garnett et al. in a cohort study including 315 children aged 7–8 years and were followed up after 7 years with 290 adolescents. The study concluded that BMI is a well-established measure in children to identify those at increased risk for CVD risk factors clustering in adolescents and there is no need to measure WC in addition to it. The author also stated other advantages such as less difficulty associated with BMI over WC which is a quick routine measure of height and weight, in contrast to WC measurements which involves locating bony landmarks (lower costal boarder and iliac crest), removal of clothing and careful placement of the tape measure to avoid fat rolls that can be uncomfortable, awkward, or embarrassing for the overweight and obese children. Considering the advantages, the author concluded BMI is a most suitable index and have the predictive power similar to WC and it will be justifiable to use BMI percentile to define overweight and obesity in predicting MS among children and adolescents. Along with advantages, BMI had a comparable or even better predictive value among 79 male Caucasian German 13-17 aged adolescents for identifying the components of MS or MS when compared with other anthropometric indices like waist circumference, waist to hip ratio and Waist to Height Ratio (WHR) with respect to power. As per the evidence from the study involving 1562 Taiwan adolescents aged 11-15 yrs, authors observed that BMI was the most significant variable amongst girls in association with terms of MS and body fat. Pearson’s correlation coefficient of BMI and body fat was 0.95 in girls in comparison to 0.81 in boys. Based on the evidence of the cohort study, BMI serial measurements are useful not only for the prediction of MS and its components in childhood but also useful for predicting risk at adulthood.

Though BMI is useful and is commonly used but there are certain limitations which are associated with it. Relationship of BMI and body fat is effected by various environmental factors like physical activity, gender, age and ethnicity. Thus while interpreting BMI of a subject for predicting of MS the above factors should also be considered.

### 1.3.3 Waist–to–height ratio

WHR used for central obesity detection and its associated health risks was first proposed in the mid 1990s. This anthropometric measure is considered to be more sensitive than BMI for early warning of health risk and can predict morbidity and mortality in longitudinal studies often better than BMI. Also significant association has been seen with all the risk factors of obesity and MS with WHR. WHR when compared with WC, the former is even more sensitive in several different populations possibly because it encompasses the adjustment to different statures. Suitability of this measure has also been validated to predict cardiovascular risk factors with DEXA and bioelectrical impedance analysis. WHR has a potential for wider use as a simple and sensitive measure for identifying central obesity. This was proved while studying 3091 black and white children aged 4-18 yrs, where in the normal weight children with central obesity had adverse levels of cardio metabolic risk factor variables as compared to those without central obesity; the overweight/obese without central obesity had significantly lower levels in relation to those with central obesity. A study with a stratified cluster representative sample of 23422 Chinese children, aged 0-18 yrs, showed that waist-to-height ratio that is equal to 0.46, could be taken as the optimal thresholds and there were significant differences for the average levels of systolic and diastolic blood pressure, serum triglyceride, high density lipoprotein cholesterol. Similar results were seen in 1665 adolescents (13–15 yrs) from Hebei province in China; children with WHR ≥ 0.46 had significantly elevated levels of fasting plasma glucose and triglycerides and
a lower level of HDL compared with the control group with WHtR<0.46. Authors concluded that it is a significant predictor of the metabolic syndrome in obese youth by studying 109 obese boys and girls, aged 10–16.5 years in Australia. Evidence from various researches and systematic review has suggested boundary value of 0.5 globally. This anthropometric measure can be easily communicated and comprehended by all age groups with simple public health message: ‘Keep your waist circumference to less than half your height’. As per the evidence from the Bogulas Heart study, BMI-for-age and waist-to-height ratio do not differ in their abilities to identify children with adverse risk factors (lipids, fasting insulin, and blood pressures). However waist-to-height ratio should be preferred because of its simplicity. It is not only appropriate tool for the research but also represents a powerful tool in the hands of pediatricians to identify obese children with high cardiovascular and metabolic risks to decide on further course of clinical investigations and interventions in these patients.

1.3.4 Neck Circumference (NC)

This anthropometric measure provides additional information for CVD risk and is measured midway between the midcervical spine and midanterior neck, just below the laryngeal prominence. NC measurement overcomes the problem of WC and waist to hip ratio as it involves no undressing and thus NC can be easily performed in winters and in busy primary care centres. This method, is not also not effected by respiratory movements, being full or in hungry state. NC shows very good inter and intra-rater reliability, which does not require multiple measurements for precision and reliability compared with WC. It has shown positive correlation with WC, BMI in overweight and obese children and thus can be used as an additional and practical tool for overweight and obesity if age and gender adjusted cut off are available. Similar results were published, where NC correctly identified high proportion of young children and adolescents who were overweight or obese (higher BMI scores). Hatiyoglu et al. in their study of four hundred twelve overweight and obese patients (208 girls and 204 boys) and 555 healthy children (284 girls and 271 boys) aged 6–18 years showed a significant and positive correlation between BMI-NC, BMI-WC and WC- NC (p < 0.001); thus it can be used as a screening tool for evaluation of obesity. Though it is an index of upper body obesity, association of it with cardio metabolic risk factors (fasting plasma glucose, insulin, total cholesterol, triglyceride and high-density lipoprotein) have been studied by author in Turkey with 581 children aged between 5-18 yrs. Findings of study showed NC was negatively correlated with HDL cholesterol and positively correlated with all other parameters, with the exception of fasting plasma glucose in pubertal boys and girls and total cholesterol in pubertal girls. Results were comparable with a study in Greece involving 324 children 3–19 yrs.

Though NC is found to have good correlation with metabolic features risk among children and adolescents but the age, sex and region specific cut off data are lacking. Also analysis of data results can also be misinterpreted in case subject has goitre or other neck masses, neck deformity, or tracheostomy or cervical collar.

2. Conclusion

With change in lifestyle choices in 21st century, there has been a shift from sound diets and physical activity centred environment, to an obesogenic environment leading to deteriorated health of children and adolescents. An example of a chronic disease observed in today’s children related to this change is the MS. MS involves constellation of CVD risk factors like obesity, high glucose level, high triglycerides and low HDL levels and there are studies indicating that MS appears even in childhood. Identification and prediction of MS at early stages is important due to sequential development of CVD and diabetes in adulthood with increased probability as compared to subjects without MS. Identifying subjects with MS through biochemical procedure is not a practical measure in epidemiological studies due to expensive, invasive techniques and the risk of contamination. Method which is suitable for predicting the subject at risk of developing MS is anthropometry. Through anthropometry, high risk subjects can be screened and further biochemical testing can be done. Although there is no perfect anthropometric method (waist circumference, BMI, waist to height ratio and neck circumference), errors could be reduced if precautions are taken such as choosing appropriate equipment, measurement protocol and providing regular training and standardisation of data collectors to maintain the validity and reliability of data. WC is a useful tool for screening early stages of metabolic aberrations but defining cut off points for defining obesity and overweight are complex; along with it, country specific cut off are lacking. BMI remains the most popular obesity
measure, overcoming the disadvantages and limitations of waist circumference. However, a BMI percentile value serves only as an indicator of relative weight but cannot distinguish between the anatomic distribution of tissues (e.g., upper/lower, central/peripheral) and may not indicate the level of central adiposity, associated with CVD risk factors. Waist-to-height ratio is recently reported as a sensitive and effective global anthropometric index of fat distribution in children at population level. WHtR and WC are convenient screening measures to assess the predictive increase in obesity and associated CVD risk factors in school screening. This tool can be easily interpreted by simple public health message “Keep the waist circumference to less than half of your height.” Another method useful for screening purpose is NC and it assesses upper fat distribution. It is easier to measure NC in comparison to waist circumference and waist to height ratio. Though the method is simple and is strongly associated in predicting the CVD risk factors among children and adolescents but the age, sex and region specific cut off and percentile are lacking. Following consideration should be kept in mind while selecting the anthropometric measure for screening of MS like age group, acceptance of method, measurement expertise, reference values for comparisons, availability of money and resources. However, WC has a significant positive correlation with triglycerides, fasting blood glucose and negative correlation with HDL-C than any other indices. But recommending any one anthropometric indices for prediction of MS is difficult because of insufficient data from cohort, case control and systematic reviews. Thus for better results, a combination of methods of generalised and abdominal obesity may be considered appropriate in prediction of MS rather than using either of them alone. Once the MS is predicted, confirmation of it can be done by biochemical testing. Once identified with MS, health education programs should be initiated with aim of primary and primordial prevention of obesity.

3. References

10. Abegunde D, Stanciole A. An estimation of the economic impact of chronic noncommunicable diseases in selected countries. World Health Organization, Department of Chronic Diseases and Health Promotion; 2006.
17. Barker DJ, Hales CN, Fall CH, Osmond C, Phipps K and Clark PM. Type 2 (non-insulin dependent) diabetes
52. Westat Inc. National Health and Nutrition Examination Survey (NHANES) III. National Center for Health Statistics (NCHS), Centers for Disease Control and Prevention (CDC); 1998.
Anthropometric Indices for the Prediction of Metabolic Syndrome and its Features, among Children and Adolescents


