Waist Circumference as an Indicator for Metabolic Syndrome in Children: A Narrative Review

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Abstract

Background: In both developing and developed nations, especially among young people, the metabolic syndrome (MetS) is a significant health concern. Risk factors include obesity, high blood pressure, low HDL-C, elevated triglycerides, and impaired glucose metabolism. They are linked pathophysiologically by the term metabolic syndrome (MetS). The pathogenesis of MetS is complex and not well understood. The syndrome may be brought on by pathogenic pathways that are activated by central obesity and/or insulin resistance (IR), which increase metabolic risk. Due to a lack of diagnostic criteria, MetS in kids and teenagers is not well understood. Post-pubertal age is predicted to have an increase in cardio-metabolic insults and MetS due to the growth in childhood cases. Early risk factor clustering is a concern since MetS elements could endure into adulthood and lead to increase the risk of developing T2DM and cardiovascular disease (CVD).

Objectives: To ascertain the importance of waist circumference as a marker of metabolic syndrome in children.

Conclusion: WC may serve as a marker for Mets in young patients.

Keywords: Metabolic syndrome; Obesity; Waist circumference.

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Introduction

Childhood obesity has increased in the previous 20 years, and so has type 2 diabetes. Because of the way their metabolism is programmed, obese children are five times more likely to become fat adults than normal-weight youngsters. Because of this, it's crucial to understand the pathophysiology, risk factors, and treatment options for children with metabolic syndrome **(Tee et al., 2017).**

The term "metabolic syndrome" was formerly more of an idea than a medical term **(Kaur, 2014).** In 1988, Reaven was the first to link metabolic syndrome and insulin resistance **. (Al-Hamad and Raman, 2017).**

In 2001, the National Cholesterol Education Program (NCEP) embraced the metabolic syndrome Obesity, hyperglycemia, hypertriglyceridemia, high-density lipoprotein (HDL), and hypertension are risk factors **(Magge et al., 2017).**

In all ages, adipose tissue buildup raises the risk of metabolic syndrome (Ms), including cardiovascular disease and impaired glucose tolerance. Hypertension and dyslipidemia are other CVD risks. Accumulation of adipose tissue elevates the risk of morbidity in children, adolescents, and adults of all ages **(Bendor et al., 2020).**

The body mass index (BMI) is a restricted indicator of total adiposity. BMI ranges were designed to account for morbidity and mortality risk. The sensitivity and specificity of BMI values for toddlers and adults are often questioned because percent of fat is used as a reference. A person's relative adiposity and energy storage capability can be predicted by body fat percentage **(Patnaik et al., 2017).**

Identification of relevant MS risk factors is a priority. Studies have linked central adiposity, especially visceral adipose tissue, to metabolic abnormalities, morbidity, and mortality. Peripheral fat depots are inversely linked to various health risk factors, therefore many studies suggest they are "protective" against weight-related disorders, including cardiovascular disease. This and other findings show that percent of body fat, a wide measurement of adiposity, may not adequately indicate health issues when compared to other clinical metrics available **(Al Hammadi et al., 2020).**

Aberrant levels of triglycerides, low-density lipoprotein, high-density lipoprotein, cholesterol, and insulin were highly associated with abdominal fat distribution in children aged 5 to 17 years old, as measured by waist circumference (WC). Easy charts can be used to achieve this method (**Ross et al., 2020**). It's unclear what health dangers young people with high belly fat pose **(Malaria et al., 2015).**

Children and teens with mets:

Definition:

MS is well-established in adults, but its use in children and teens is still contested **(Shamim, 2019).**

There's no international consensus on how to describe MetS in kids and teens. There are various classifications, and most researchers utilise adult norms **(Shamim, 2019).**

According to consensus, four requirements must be met In order: abdominal obesity, arterial hypertension, dyslipidemia, hyperinsulinemia, altered glucose metabolism, and insulin resistance (**Wang et al.,2020**).

The International Diabetes Federation (IDF) says abdominal obesity and two or more clinical characteristics are the most common MetS criteria for adolescents. To identify WC, percentile curves are used for each age group and gender **(Weihe et al.,2019).**

MetS criteria for kids aged 10_16 years were triglycerides below 150 mg/dL, HDL below 40 mg/dL, SBP or DBP below 130 or 85 mg/dL, and fasting glucose below 100 mg/dL. Triglycerides 150 mg/dL, HDL 40 mg/dL for boys and 50 mg/dL for girls , SBP 130 mmHg or DBP 85 mmHg, and fasting glucose 100 mg/dL **(Lin et al.,2017).**

MetS may be hard to define in general due to anthropometric and metabolic differences amongst ethnic groups. To diagnose abdominal obesity, dyslipidemia, hypertension, and altered glucose metabolism, racial and ethnic cutoff points and percentiles must be used. Some studies use reference values from other demographic groups when these percentiles aren't available **(Agirbasli et al., 2016).**

Table 1.Various metabolic syndrome diagnosis criteria for kids and teenagers (cook et al).

Diagnostic criteria	Having central obesity and at least two out of the four characteristics.	3 or more criteria.
"Central obesity	WC 90th percentile or, if below, adult cut-off	90th percentile for WC
Hypertension	SBP greater than 130 mmHg, DBP less than 85 mmHg, or by the usage of anti-hypertensives.	90th percentile for BP
Hypertriglyceridemia	150 mg/dL for triglycerides	More than 110 mg/dL for TG
low level of HDL	40 mg/dL high density lipoprotein	About 40 mg/dL HDL
altered glucose level	100 mg/dL of FPG, or known Type Two diabetes,	110 mg/dL Fasting plasma glucose level (FPG).

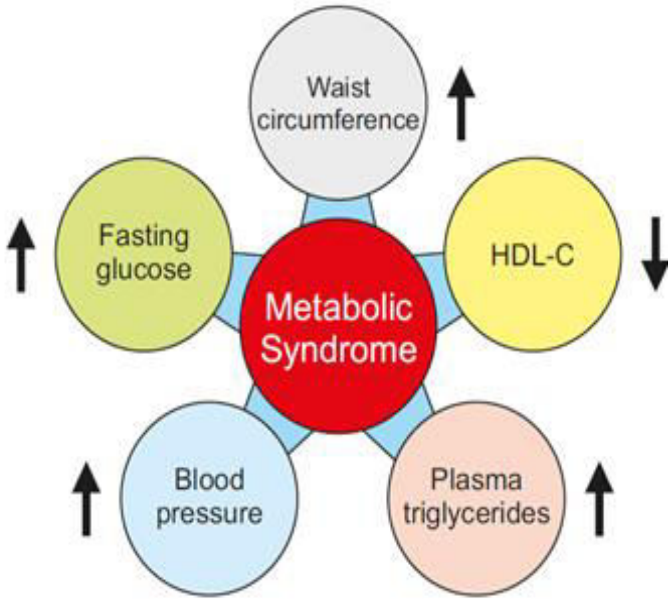

Fig.1. Criteria for determining the metabolic syndrome's clinical diagnosis in children and adolescents (Wang et al., 2020).

Epidemiology

Adults and teens worldwide have metabolic syndrome. Health care costs are higher in urban areas **(Vaquero Alvarez et al., 2020).**

Because of the disorder's many categories, it's hard to establish its incidence in youngsters **(Al-Hamad and Raman, 2017).**

MetS affects 3.3% to 38.9% of kids globally. More people were overweight (11.9%) and obese (29.2%). MetS prevalence in HICs has risen with childhood obesity **(Swinburn et al., 2019).**

Obesity has increased over the past 40 years due to lifestyle choices like soda, juice, and baked goods . MetS rose from 6% to 39% due to childhood obesity**(Bitew et al.,2012).**

Metabolic syndrome is 3.3% (0-19.2%) prevalent in communities, 11.9% (2.8-29.3%) in overweight children, and 29.2% (10-66%) in obese groups. 0-1% of non-obese groups **(Friend et al., 2013).**

90% of obese kids have metabolic syndrome. Hispanics are affected more than whites or blacks **(Wittcopp and Conroy, 2016).**

MetS pathogenesis

The pathogenesis of metabolic syndrome is poorly understood. A new study found that obesity, insulin resistance, and inflammation may all increase the incidence of type 2 diabetes. **(Wittcopp and Conroy, 2016).**

Free fatty acids in obese people's pancreas, muscles, and liver may impede insulin signalling and cause insulin resistance. Insulin resistance hinders the liver's ability to reduce glucose production **(D'Adamo et al. ,2013).**

Hyperinsulinemia accelerates the liver's lipogenic enzyme gene transcription. Triglyceride synthesis rises, and the liver is less sensitive to insulin's VLDL-inhibiting effects. Triglyceride synthesis increases VLDL production **(Meshkani and Adeli, 2009).**

Hyperinsulinemia causes metabolic syndrome's high blood pressure through sympathetic overactivity, renal salt retention, and fast smooth muscle development. Insulin creates more of the vasodilator nitric oxide. Insulin dilates the endothelium. Migration of macrophages may enhance dysfunctional adipocytes' production of inflammatory cytokines, leading to more cytokines. Obesity lowers adiponectin levels, which may promote inflammatory responses in adipose tissues **(Wittcopp and Conroy, 2014).**

Clinical characteristics of the metabolic syndrome :

Typically, the following clinical characteristics are recognized as being related to metabolic syndrome:

Obesity is an important contributor to the development of type 2 diabetes, cardiovascular disorder , and the metabolic syndrome **(Wittcopp and Conroy, 2014).**

This is abundantly clear when one considers the strong connection that exists between the incidence of metabolic syndrome, insulin resistance, and the level of obesity. The body mass index (BMI) measures obesity; individuals are deemed obese if their BMI is more than the 95th percentile for their age and gender. Patients diagnosed with metabolic syndrome are most likely to have the following clinical characteristics:

Obesity: Obesity has been shown to have a significant influence on the development of metabolic syndrome, type 2 diabetes, and cardiovascular disease **(Wittcopp and Conroy, 2014).**

This assertion is supported by abundant research, including the considerable correlation that exists between the frequency of metabolic syndrome and insulin resistance and the amount of obesity in a population. The body mass index (BMI) is a method for determining whether or not a person is obese. According to this method, a person is considered obese if their BMI is more than the 95th percentile for their gender and age. If a person's body mass index (BMI) is higher than the 85th percentile or lower than the 95th percentile in children, then that individual is regarded to have an unhealthy content of body fat. Additionally , visceral fat deposition is strongly linked to metabolic syndrome in younger individuals and cardiovascular disease in older people, and this association holds true regardless of the degree to which a person is obese**, (Wittcopp and Conroy,2014).**

There are not enough data on paediatric reference ranges that waist circumference can be used as a regular part of the evaluation for paediatric obesity, **(Khoury et al., 2013).**

In patients who have dyslipidemia, an increased ratio of triglycerides to high-density lipoprotein (HDL) may indicate a rise in LDL . When the ratio is three or above, there is a greater presence of more minute, dense LDL particles in the blood. It is likely connected to a higher likelihood of developing cardiovascular disease **(Burns et al., 2012)..**

The most prominent part of metabolic syndrome, high blood pressure, has long been recognised as a modifiable risk factor for cardiovascular disease, **(Saklayen, 2018).**

Deteriorating beta-cell activity leads to a loss in insulin production capacity, the development of type 2 diabetes (T2DM), insulin resistance, and glucose intolerance. **(Standards, 2017).**

Non-alcoholic fatty liver disease (NAFLD) is the most prevalent kind of liver disease found in youngsters. The rise in it is paralleled with the prevalence of childhood obesity among children. Although asymptomatic steatosis is the least severe form of liver disease, non-alcoholic steatohepatitis (NASH) can develop into hepatocellular carcinoma. Insulin resistance may promote fat buildup in the liver, as well as a condition known as macrovascular hepatic steatosis **(Mencin and Lavine, 2014).**

Polycystic ovary syndrome (PCOS) is typically associated with insulin resistance as well as obesity in adolescent girls. PCOS is the root of the hyperandrogenism problem. PCOS increases the risk of developing metabolic syndrome; this is true regardless of the patient's weight or insulin resistance**,(Conroy and Wittcopp,2016).**

Visceral adipocytes' production of inflammatory cytokines is increased with obesity, including three different markers of inflammation, c reactive protein(CRP) , tumour necrosis factor-alpha (TNF-alpha), and interleukin-6 **(Korner et al., 2007).**

Adults' potential for developing cardiovascular disease can be evaluated with CRP levels. Even though the specific relationship between CRP and metabolic syndrome in children is unclear, CRP and insulin resistance are connected in obese children and teens. This correlation exists in obese children and teenagers who have high CRP levels. Young children exhibit this link **(Oliveira et al., 2008).**

Screening tools

When metabolic syndrome is identified in childhood, it may be possible to reduce its consequences on adult cardiometabolic health as well as the costs to the public health system. A crucial technique **(Kaur et al., 2014).** Monitoring the health of teenagers on a routine basis might be difficult because diagnosing metabolic syndrome requires laboratory tests to detect the plasma lipid profile and glycemic rate **(Poyrazoglu et al., 2014).**

According to the findings of a previous study, an excessive amount of body fat may be a major contributing factor in children and adolescents who have MetS,**(Melka et al., 2013).**

The neck circumference (NC) has been proposed as a method for determining the presence of MetS in adults by a number of researchers. Other investigations predicted the existence of metabolic syndrome in teenagers based on their neck circumference, body mass index (BMI), waist circumference, waist-hip ratio, waist-height ratio, skinfold thickness, conicity index, and fat and lean BMI **(Carneiro et al., 2014).**

It is essential to conduct research on the predictive utility of anthropometric signals and their cut-off points in order to diagnose MetS in young populations. Due to the fact that body fat tests are easy, they do not involve any invasive procedures, and they are reasonably priced **(Oliveira and Guedes, 2018).**

Anthropometric markers can be used in settings where there is a high concentration of children, such as schools. This makes it possible to target more adolescents, particularly those who have difficulty gaining access to the healthcare system or who do not make use of its services. Teenagers who are found to be at risk for MetS and who have received a diagnosis may be sent to a specialist **(Oliveira and Guedes, 2018).**

Children who are overweight or obese and are at risk of developing type 2 diabetes and heart disease should be identified by medical professionals (CVD). These children need to be evaluated for behavioural problems, medical diseases such as chronic obesity, and any co-morbidities that are related to obesity. Since having one or both obese parents is a risk factor for a child developing obesity, it is important that this information be taken into consideration during the screening process **(Kumari et al., 2019).**

Comorbidities are evaluated with the use of a physical examination and a patient's medical history. The patient's comorbidities, such as PCOS, obstructive sleep apnea, and liver illness, must be brought up by the treating clinician **(Fornari and Maffeis, 2019).**

The HOMA-IR test measures one's insulin resistance. It is not possible to give the HOMA-IR test to both adults and adolescents in the same manner. Insulin sensitivity drops during puberty for certain people **(Comlek et al., 2022).**

Children who are obese and over the age of 10 and have a first or second-degree relative who has type 2 diabetes should have an oral glucose tolerance test with 75 grammes of glucose administered at a rate of 1.75 grammes per kilogramme. The American Disability Act (ADA) recommends administering the test in the following scenarios **(ADA, 2018).**

The levels of ALT and AST that are found in the serum can be utilised to accurately diagnose fatty liver disease. A paediatric hepatologist ought to examine a young child because their levels are twice as high as the maximum allowable level **(Fornari and Maffeis, 2019).**

For children under the age of 10 who are obese or overweight and have more risk factors, screening for liver disease should begin at age 10 and take place every other year **(Temple et al., 2016).**

Tests for type 2 diabetes should be performed on children and adolescents who have two risk factors in addition to being overweight or obese. A mother who had gestational diabetes during the child's pregnancy or who has a history of diabetes, as well as at-risk ethnicity (Native Americans, African Americans, Latino Americans, Asian Americans, and Pacific Islanders), symptoms of insulin resistance, or associated conditions such as acanthosis nigricans, hypertension, dyslipidemia, or PCOS, are all risk factors for type 2 diabetes in children **(Al-Hamad and Raman, 2017).**

It is recommended that a non-fasting, non-HDL lipid profile be performed on all children aged between 9 and 11 years in order to screen for dyslipidemia. It is highly recommended to utilise comprehensive lipid screening. The fasting lipid levels of overweight children between the ages of 2 and 8 should be evaluated. Obesity is a risk factor that ranges from moderate to high. A lipid profile is recommended by the National Heart, Lung, and Blood Institute (NHLBI) for children and adolescents aged between 12 and 16 who are overweight.

Indicators of the metabolic syndrome based on anthropometric measurements

In order to successfully reduce adult cardiometabolic issues, early finding of metabolic syndrome in the young people is an essential component. This is one of the essential preventative actions that can successfully aid to contribute to a reduction in the risks of cardiometabolic conditions in adults. Numerous people have the opinion that this tactic is of the utmost significance **(Kaur et al., 2014).**

It is a difficult task to integrate MetS extensively into the regular screening of the health status of teenagers since it requires a multitude of different laboratory tests to analyse the plasma lipid profile and glycemic rate **(Poyrazoglu et al.,2014).**

Establishing the predictive value of each anthropometric measure as well as its cut-off points is necessary in order to identify instances of metabolic syndrome in younger populations. It is especially essential to keep in mind this fact due to the fact that anthropometric measurements of the total amount and distribution of body fat are not only low-cost but also straightforward and do not require any form of invasive physical testing, **(Motamed et al., 2015).**

•Body mass index

Adults and children's nutritional status is increasingly assessed by BMI (BMI). The body mass index isn't a reliable way to measure adipose tissue distribution **(Perona et al., 2018).**

The BMI formula divides a person's weight in kg by their height in m2. This method follows WHO's age-and gender-based BMI standards, **(Weber et al., 2014).**

The International Obesity Task Force, the CDC in the US, and the WHO have all proposed the body mass index (BMI) for age and gender, using percentile-based criteria, as a screening tool for adiposity and a measure for cardiometabolic risk. The International Obesity Task Force recommends using BMI percentiles for age and gender **(Sardinha et al., 2016).**

BMI cannot split between fat mass and other types of mass. Having a high BMI doesn't automatically mean a person is overweight, **(Ochoa-Sangrador et al., 2018)**

• Waist Circumference

The 90th percentile of waist circumference is the cutoff value suggested by the International Diabetes Federation (IDF) for determining central obesity. This is because it's possible that measuring visceral fat by the waist circumference (WC) can be helpful. WC has been asserted to be a reliable predictor of visceral fat, although it is not likely that WC and BMI will result in an appropriate assessment of visceral fat. This is due to the fact that BMI measures total body fat, **(Arellano-Ruiz et al., 2020).**

However, employing a direct measure of adiposity, such as body fat percent, has no advantages over using a surrogate measure of adiposity, such as BMI or WC. This is accurate that both BMI and WC are utilised as markers of obesity. The waist circumference (WC) has been used as a marker of central adiposity due to its high degree of sensitivity and high degree of specificity. More accurately and consistently than the BMI, this indicator has shown favourable correlations with cardiovascular disease risk factors, **(Fernandes et al., 2009).**

•Waist-to-height ratio

The waist-to-height ratio (WtHR), which has recently been proposed as a potential more accurate predictor of risk and is more sensitive as an early warning of health danger, allows for the same boundary values across sex, age, and different ethnic groups. The WtHR is then able to calculate waist size in proportion to height. The WtHR measurement, which compares height and waist circumference, must be used, **(Bauer et al., 2015).**

At the point where the lowest rib meets the top of the iliac crest during the exhalation phase, the waist circumference is measured. The iliac crest's midpoint is at this location. The measuring tape was wrapped around the greatest part of the buttocks in order to obtain an accurate measurement of the hip circumference, **(Arnold et al., 2014).**

Numerous studies have demonstrated that having a WtHR larger than 0.5 is a good predictor of higher cardiometabolic risk, which is in accordance with the hypothesis that your waist circumference should be less than half your height. This is accurate if you use the guideline that your waist measurement shouldn't be greater than half of your height. This measurement has been suggested as a reliable and uncomplicated method of diagnosing central obesity, **(Ashwell and Gibson, 2014).**

There is no agreement on the proper WtHR cutoff that should be used to identify children who are at risk for cardiometabolic disease because numerous research have suggested various cutoff values of WtHR to precisely detect children who are at cardiometabolic risk. This results from the widespread adoption of various WtHR cutoff values by studies to particularly identify children at risk for cardiometabolic illness, **(Khoury et al., 2013).**

• Neck circumference

Recent studies suggest that adult populations with metabolic syndrome may benefit from using neck circumference (NC) as a diagnostic tool, **(Pereira et al., 2014).**

Other research suggests predicting MetS in children using the NC, BMI, waist-hip ratio, skinfold thickness, conicity index, and fat and lean body mass index (BMI). These parameters were measured for the study participants. By measuring the child's hip circumference to their waist circumference, this was calculated **(Weber et al., 2014).**

More recently, "The ERICA Study," a sizable research project in Brazil, was carried out with the purpose of determining the incidence of the metabolic syndrome as well as its particular elements in a sizable sample of Brazilian teenagers, **(Kroll et al., 2017).**

To the best of our knowledge, no study has compared six distinct anthropometric measures across the same cohort to identify MetS in healthy Brazilian teenagers. There isn't any such research, hence this is correct. Body mass index (BMI), neck circumference, triceps skinfold, subscapular skinfold, and body fat percentage (BF%) are the measurements employed in this study **(Kelishadi et al., 2017).**

Waist circumference as an indicator of metabolic syndrome in children

To determine whether or not a person has central obesity, the International Diabetes Federation (IDF) suggests using a cutoff that corresponds to the 90th percentile of waist circumference. This is related to the idea that one's waist size can properly predict the amount of visceral fat that they have. Visceral fat, on the other hand, does not appear to be able to be correctly quantified by waist circumference and body mass index, **(Arellano-Ruiz et al., 2020).**

There are times when the waist circumference(WC) is used as a representation of visceral adipose tissue. Accurate evaluation of visceral adipose tissue can be accomplished by the use of imaging techniques as pelvic-abdominal computed tomography, magnetic resonance imaging, and x-ray absorptiometry, among others. Despite this, the efficacy of these imaging techniques is severely hindered by the prohibitive cost involved and the difficulty in gaining access to them. Studies showed that the waist circumference can be utilised as a predictor for individuals' likelihood of developing cardiovascular disease and type 2 diabetes mellitus. The WC applies the same criteria to the evaluation of visceral body fat, **(Trandafir et al., 2020).**

The most accurate anthropometric predictor of metabolic syndrome in children was developed by Moreno and colleagues. The body mass index serves as the foundation for this forecast. When it comes to screening for metabolic syndrome, the authors state that measuring the waist circumference appears to function in a manner that is comparable to that of testing the BMI**, (Moreno et al., 2007).**

Maffeis and colleagues discovered that children with waist circumferences greater than the 90th percentile are more exposed to a variety of risk factors than children with waist circumferences less than or equal to the 90th percentile. This is because children with waist widths beyond the 90th percentile are more likely to have larger body mass indices, **(Maffeis et al., 2001).**

The waist circumference, rather than the body mass index, was found to be a more accurate predictor of the risk variables linked with cardiovascular disease in a study that was conducted by Savva and colleagues. The measurement of a child or adolescent's waist circumference can be used as an additional way for identifying whether or not they have an unhealthy amount of overall body fat. The circumference of the child's or adolescent's waist is the best way to determine this, **(Savva et al., 2000).**

A research study utilising a cross-sectional design was carried out by Mahrous et al. on a total of 455 students enrolled at the educational establishment. It was discovered that female students had a much higher prevalence of mets than male students did, as compared to other students. An increase in waist circumference is one of the hallmarks of metabolic syndrome, and this particular symptom was detected 41.8% of the time. It was demonstrated that the incidence of MetS increased considerably as WC did so, **(Mahrous et al., 2018).**

An investigation that was carried out in Egypt utilised a cross-sectional methodology, and it involved the participation of two hundred Egyptian teenage girls. When they came together, their ages ranged anywhere from 12 to 18. The outcomes of the study revealed that female patients diagnosed with MS had WC values that were much higher than those recorded for male patients, (**Hassan et al., 2019).**

596 healthy secondary school students from Dubai's public schools participated in the study, which was just published and is considered to be significant. The study was conducted in Dubai. Participants' ages ranged anywhere from ten to fifteen and a half years, and the study comprised a total of 308 boys and 288 girls. According to the authors of the study, there was a statistically significant rise in the prevalence of biochemical risk variables that were classified as high or borderline in the group that had a high waist circumference when compared to the group that had a normal waist circumference. Students who had a big waist circumference had considerably higher levels of triglycerides and low-density lipoprotein than students who had a normal waist circumference. This was a comparison made between two groups of students (LDL). The overall results showed that there was an inverse relationship between the diameter of the waist and HDL levels, and that students who had normal waist sizes had much greater HDL levels than those who had bigger waists. In addition to this, they discovered that those with a large waist circumference were the only ones who had at least four MetS risk characteristics. All biochemical markers, including glucose, cholesterol, low-density lipoprotein (LDL), and triglycerides, were found to have a positive and significant correlation with BMI z-scores, waist circumference, and waist-to-hip ratio, with the exception of cholesterol. This was the case even though cholesterol was included in the study. The only component that has showed an inverse connection with the other factors that is statistically significant is HDL cholesterol, **(Haroun et al., 2018).**

An Egyptian study followed a similar line of inquiry and included 56 obese children who had body mass indices that were higher than the 95th percentile for their age and gender. As a control group, the study also included fifty kids of the same age and gender as the participants, but who maintained a healthy weight throughout the duration of the investigation. When compared to the control group, both the mean BMI percentile and waist circumference of the obese group were considerably greater than those of the control group. It was able to distinguish this difference using statistical methods. A statistically significant difference in waist circumference was found between the groups of obese children with and without metabolic syndrome, **(Atwa et al. 2012).**

Conclusion

WC might be regarded as a marker for Mets in young people.

Conflict of Interest:

There are no potential conflicts of interest for the authors of this study in relation to this publication.

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