JMS 2021;4(2):147-155
UDC:613.25:572.087.1]-053.5(497.7)

ANTHROPOMETRIC INDICES FOR ESTIMATING OVERWEIGHT AND OBESITY IN SCHOOL-AGED CHILDREN FROM NORTH MACEDONIA

Biljana Zafirova, Elizabeta Chadikovska, Biljana Trpkovska, Biljana Bojadgieva Stojanoska
Institute of Anatomy, Faculty of Medicine, Ss. Cyril and Methodius University in Skopje,
R. North Macedonia

Abstract

Anthropometrics are a set of non-invasive, quantitative body measurements used to assess growth, development and health parameters. Waist circumference (WC) and waist -to-hip ratio (WHR) are the measurements most commonly used to estimate abdominal obesity while BMI used to determine general obesity.

Our goal in this study was to find cut-off points of selected anthropometric indices for estimating overweight and obesity in school-aged children aged 6 to 8 years from North Macedonia.

In this study, a total of 603 children (300 boys and 303 girls) were investigated. Anthropometric indicators were measured using a standard protocol. We selected four parameters to measure (weight, height,) and two circumferences (waist WC and hip HC). The following indices were taken into consideration: Body mass index (BMI), WC and waist-to-hip-ratio (WHR). Percentile distribution of the tested variables was done by age and sex.

Some of anthropometric parameters have shown significant age- and sex-specific differences in favour of boys, with exception of WHR. The prevalence of overweight and obesity across BMI cut-off points was 16% in boys and 15, 1% in girls. Girls had the prevalence of abdominal obesity of 12 % WC and WHR 13,2%. Both cut-off points for the boys were 11% WC and 10% WHR. However, the Macedonian cut-off points for WC and WHR showed a slightly elevated prevalence of abdominal obesity among girls

These results and determination of BMI, WC, WHR cut-off values can be used for estimating overweight and obesity and consequences associated with it in school-aged children aged 6 to 8 years from North Macedonia.

Kew words: BMI, WC, WHR, school-age children, anthropometry

Introduction

Childhood obesity is a major national public health concern [1]. Obesity is now considered a global epidemic because its prevalence and severity both in adults and children has been increasing worldwide at alarming rates.

The prevalence of obesity was 19.3% and affected about 14.4 million children and adolescents. Obesity prevalence was 13.4% among 2- to 5-year-olds, 20.3% among 6- to 11-year-olds, and 21.2% among 12-to 19-year-olds [2].

Also, approximately one-fourth of children worldwide are obese or overweight. Seventy percent of obese teenagers develop into obese adults [3].

It has been shown that childhood overweight and obesity are related to adverse levels of cardiovascular disease risk factors in adulthood. Obesity during childhood is associated with the development of insulin resistance, diabetes, and cardiovascular disease (CVD) throughout the lifecycle [4].

The increase in childhood obesity prevalence is related to an increasingly sedentary lifestyle (computer games and watching TV) with recreational physical inactivity as well as changing dietary habits consumption of high-calorie foods and inappropriate diets) [5].

Different anthropometric indicators are used to determine general obesity and abdominal obesity [6]. Body mass index (BMI) is a simple indicator of the connection between weight and height that is frequently used to indirectly identify overweight and obesity [7].

This indicator is simple, easy to calculate, and has clearly defined cut-off points to determine general obesity.

Waist circumference and WHR indices are two simple, yet effective, surrogate measures of abdominal obesity. Central or abdominal obesity has been associated with the risk of cardiovascular and metabolic disease in children [8].

Our goal in this study was to find cut-off points of selected anthropometric indices for prediction of overweight and obesity and to analyze the prevalence of obesity in school-age children aged 6 to 8years.

Material and methods

Subjects

The study included healthy school-age children from both sexes aged 6 to 8 years living in Skopje, R. North Macedonia. It excluded children with systemic and metabolic diseases that may affected on growth and development of children, as well as those children with family history of systemic illness. The total number of subjects (n=603) was divided into subgroups by sex and age: 300 boys (100 from each age 6,7 and 8 years) and 303 girls (101 also from each age respectively).

Anthropometry

Anthropometric indicators were measured using a standard protocol [9]. When the measurements were done, the children were wearing light clothes (T-shirts and shorts), they removed their shoes and their anthropometric points and levels were previously marked. The following anthropometric parameters were measured: weight, height, waist circumference (WC) (measure at the end of several consecutive natural breaths, at a level parallel to the floor, a midpoint between the top of the iliac crest and the lower margin of the last palpable rib in the midaxillary line) and the hip circumference (HC) measured at a level parallel to the floor, at the largest circumference of the buttocks [9,10].

The instruments for measuring were standard and were regularly calibrated before measuring; their precision was controlled throughout the entire measurement process. The following standard anthropometric instruments were used: anthropometer by Martin for measuring height with a reading precision of 1 mm; medical decimal scales for measuring weight with a precision of 0.1 kg; stretch-resistant tape for measuring circumferences with a precision of 1 mm. The following indices were taken into consideration: BMI (dividing the weight by the square of the height) and WHR (waist divided by hip circumference).

Definitions

For the aim of categorization of the anthropometric indices' values, the following percentile cut-off points were used: <5th percentile for the category of extremely low values or underweight; from the 5th to less than the 85th percentile for mean values normal or healthy weight; from the 85th to less than the 95th percentile for the category of overweight or category of above average values; and 95th percentile or grater for obese and for extremely high values; for WHR and WC-for-age>=90th percentiles were considered high values or abdominal obesity [11-14].

Statistics

The gathered data for the relevant variables were analyzed with descriptive statistics represented by central tendency and its deviation (arithmetic mean ± standard deviation) and percentage. BMI, WC and WHR were distributed by pc (5th, 25th, 50th, 85th, 90th, and 95th pc) according to age and sex. Testing of sex-differences was done with analysis of variance for large, independent samples-ANOVA. Differences for $p < 0.05$ were considered significant.

Results

The study included a sample of 603 school-age children from both sexes aged 6 to 8 years, of whom girls were 303 or 50.25% and boys 300 or 49.75%. The mean age (±sd) was 7 (±0.82) years. Descriptive statistics (mean values and standard deviations) of the examined anthropometric indicators: weight, height, BMI, WC, HC and WHR, in school-aged children aged 6, 7 and 8 years and their sex and age differences (ANOVA- test) are presented in Table 1.

Our male subjects had body height of 126.03 ± 7.59 cm, weight of 28.79 ± 7.05 kg, BMI of 17.89 ± 2.89 kg/m^2, WC of 60.34 ±7.93cm, HC of 67.79±7.39cm and WHR of 0.891±0.08. Mean values of all anthropometric variable in the 6-7-8-year-old boys increased significantly, except for WHR which does not show age specific differences.

These parameters also increased with age in the girls while WHR showed the opposite behavior in both sexes. Our female subjects had body height of 124.69 ± 7.72 cm, weight of 26.88 ± 7.72 kg, BMI of 17.09 ± 2.61 kg/m^2, WC of 58.52 ±8.16cm, HC of 66.7±6.86cm and WHR of 0.876±0.07.

Comparison of these anthropometric parameters between boys and girls showed sex-specific differences in favour of boys for certain parameters, except for WC, HC WHR at age 6 and 7, BMI and height at age of 7 and 8 and weight and HC at age of 8. Despite the fact that some parameters did not show significant statistical differences, their mean values were higher than boys.

Table 1. Mean and standard deviations and sex and age specific differences of examined anthropometric indicators among Macedonian school-age children (n=603).

Age/years	n	Weight (kg)	Height (cm)	BMI (kg/m^2)	WC (cm)	HC (cm)	WHR
Girls							
All	303	26.88±4.67	124.69±7.72	17.09±2.61	58.52±8.16	66.7±6.86	0.876±0.07
6	101	23.07±4.57[a]	118.59±5.93[a]	16.27±5.93[a]	55.51±7.85[a]	62.69±6.26	0.884±0.07
7	101	26.63±5.43[a]	124.71±5.59[a]	17.01±2.59[a]	58.76±7.54	66.78±6.45	0.87±0.05
8	101	30.94±6.22	130.78±6.21	17.98±2.78	61.28±8.13	70.61±5.45	0.86±0.07
Boys							
All	300	28.79±7.05	126.03±7.59	17.89±2.89	60.34±7.93	67.79±7.39	0.891±0.08
6	100	25.58±5.37[a]	120.19±5.76[a]	17.43±2.51[a]	56.67±6.93	63.76±7.96	0.896±0.12
7	100	28.23±5.84[ba]	126.07±4.93[ba]	17.71±3.01[ba]	60.46±7.27[b]	67.8±5.79[b]	0.890±0.06
8	100	32.59±7.85[b]	131.82±6.95[b]	18.54±3.02[b]	63.89±7.92[b]	71.8±5.97[b]	0.88±0.05[a]

Values are mean ±SD=Standard deviation, BMI=Body Mass Index, WC=Waist Circumference, HC=Hip Circumference, WHR=Waist-Hip Ratio

[a]p<0.05 *vs* 6,7 and 8- year- old children (ANOVA)

[b]p<0.05 *vs* girls of the same age (ANOVA)

The table 2,3 and 4 show distribution by pc (5th, 25th, 50th, 85th, 90th, and 95th) of BMI, WC and WHR in our subjects by age and sex.

Table 2. Percentile distribution of BMI by sex and age for Macedonian school-aged children

Age/years	n	5	25	50	85	90	95
Girls							
6	101	13.12	14.46	16.08	18.74	19.25	19.7
7	101	13.64	15.27	16.61	19.54	20.39	22
8	101	14.63	15.85	17.35	21.5	22.1	22.5
Boys							
6	100	13.6	15.63	17.08	20.5	21.04	22.3
7	100	14.37	15.69	17.2	20.6	21.2	23
8	100	15.69	16.51	17.86	21.3	22.2	23.3

Table 3. Percentile distribution of WC by sex and age for Macedonian school-aged children

Age/years	n	5	25	50	85	90	95
Girls							
6	101	45	50	53	67	68.6	69.8
7	101	48	53	56.5	69	70	72
8	101	50	55.5	60	70	73	74
Boys							
6	100	49	52	54	66.1	68.1	70
7	100	50.9	54	60	69.5	70.1	73
8	100	52.4	55	63.9	74	75	76

Table 4. Percentile distribution of WHR by sex and age for Macedonian school-aged children

Age/years	n	5	25	50	85	90	95
Girls							
6	101	0.79	0.838	0.87	0.97	0.98	1
7	101	0.78	0.835	0.88	0.93	0.94	0.94
8	101	0.73	0.82	0.86	0.94	0.96	0.98
Boys							
6	100	0.73	0.84	0.88	0.97	1	1.14
7	100	0.78	0.85	0.9	0.94	0.98	0.99
8	100	0.80	0.88	0.88	0.95	0.96	0.97

The figure 1 and 2 shows prevalence across BMI cut-off points for our boys and girls at aged 6 to 8 years.

In the present study, the number of boys and girls with underweight, normal weight, overweight and obesity across BMI cut-off points was, for boys:15 (5%), 237 (79 %), 31 (10.3%) and 17 (5.67%), respectively and for girls 15 (5%), 242 (79,9 %) 30 (9,9%) and 16 (5,2).

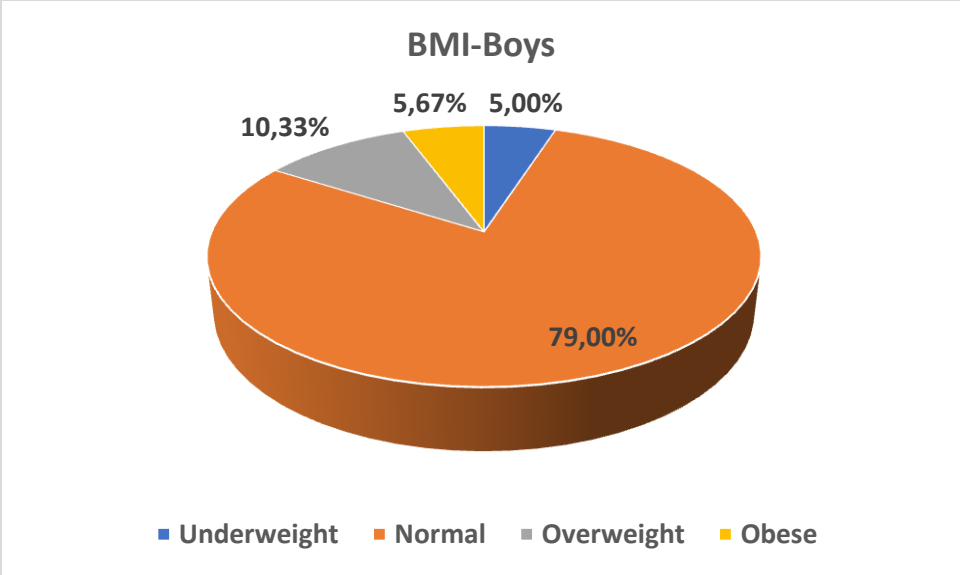


Fig. 1. Prevalence of obesity across BMI cut off points for Macedonian school-age children, boys

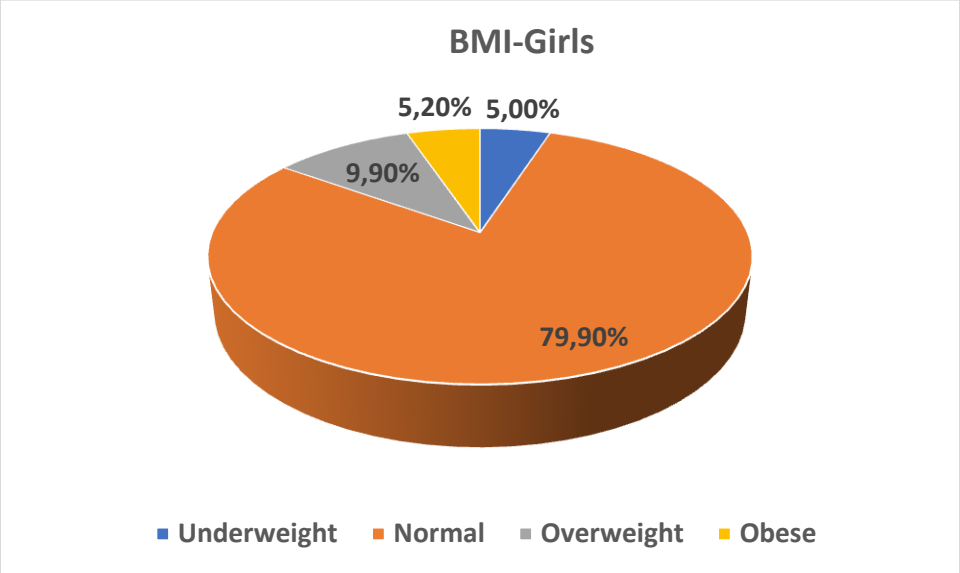
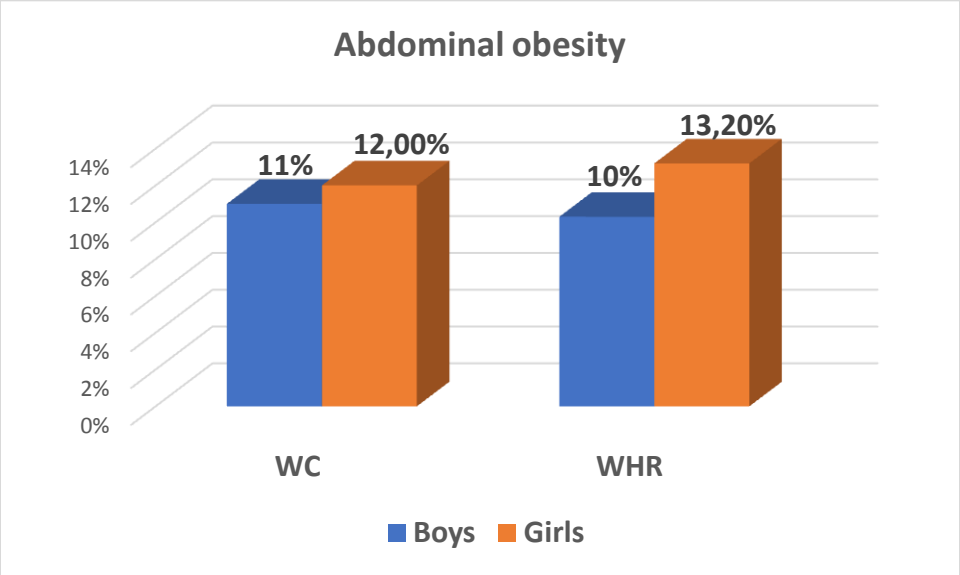


Fig.2. Prevalence of obesity across BMI cut off points for Macedonian school-age children, girls

The graphic 1 show prevalence of central or abdominal across WC and WHR cutoff points for our boys and girls at aged 6 to 8 years.

In the examined population of girls, abdominal or central obesity for WC were registered in 35 girls or (12%) and based on WHR in 13.2%. or 40 girls. Both cut-off points for boys were similar with the same values for girls respectively.

The prevalence of abdominal obesity in boys was 11 % or 33 boys for WC and 10 % for WHR or 31 boys. However, the Macedonian cut-off points for WC and WHR showed a slightly elevated prevalence of abdominal obesity among girls.



Graph 1. Prevalence of central or abdominal across WC and WHR cut off points among Macedonian school-age boys and girls aged 6 to 8 years

Discussion

This study was designed to establish values for anthropometric indicators, their sex and age differences as well as cut-off points which are used for assessment of overweight and obesity in children.

Age- and sex-specific differences related to certain anthropometric parameters were observed in favour of male subjects, and this results in agreement with the results reported in other anthropometric studies [15-17].

The obtained values enabled comparison with corresponding anthropometric researches in children from other regions and populations [18].

BMI is used commonly to classify obesity among adults, and also is recommended for use with children and adolescents. It is often used to measure general adiposity and to classify children and adolescents as “underweight”, “normal weight”, “overweight”, or “obese”. Cutoff criteria are based on the sex-specific BMI-for-age. Cole et al. have established the first age- and sex-specific BMI cut-off values to detect overweight and obesity. He used a reference sample that largely preceded the obesity epidemic to derive the IOTF [20].

Similar values have been created by the World Health Organization and the Centers for Disease Control [13,17,19,20].

Based on recommendations from expert committees, children and adolescents with BMI values at or above the 95th percentile of the growth charts are categorized as having obesity.

Results from the 2017–2018 National Health and Nutrition Examination Survey (NHANES), using measured heights and weights, indicate that an estimated 19.3% of U.S. children and adolescents

aged 2–19 years have obesity, including 6.1% with severe obesity, and another 16.1% are overweight [19].

In our study prevalence of obesity across BMI based on the CDC cut-off points among Macedonian school-aged children aged 6 to 8 years were: 10. 33 % of boys were overweight and 9.9 % were girls at the same age, while 5.67% boys were obese and 5.2 % girls respectively.

Comparison of cut-off values of BMI for the 85th and 95th percentile of our respondents school-aged children 6 to 8 years with values of IOTF

Cut-off values of BMI for 85th and 95th percentile were higher in our boys at the age of 6 years (20.5 and 22.3 kg/m^2) than in the boys examined by the International Obesity Task Force (IOTF) (17.7 and 20.2 kg/m^2) [20]. BMI values in our girls aged 6 years were 18.74 kg/m^2 for the 85th percentile and 19.7 kg/m^2 for the 95th percentile against the relevant results of 17.5 kg/m^2 for the 85th percentile and 20.1 kg/m^2 for the 95th percentile.

BMI values in our 7-year-old boys had the following values for the 85th percentile and the 95th percentile: 20.6 and 23.04 kg/m^2 for boys and 19.54 and 22.6 kg/m^2 for girls against those reported by IOTF: 18.2 and 20.6 kg/m^2 for 7-year-old boys and 18 and 20.5 kg/m^2 for 7-year-old girls.

The percentile values of BMI in 8-year-old boys from our study on the so-called cut off points on the 85th percentile are 21.3, i.e. 23.3 on the 95th percentile and are higher than the international sample published by Cole et al. which shows a value of 18.69 for the 85th percentile and 22.17 for the 95th percentile. Girls also have a higher value of BMI on the corresponding points: 21.5 for the 85th percentile and 22.5 for the 95th percentile as opposed to the published 18.76 for the 85th percentile and 22.18 for the 95th percentile [20].

Waist circumference (WC) and waist-to-hip ratio (WHR)

Waist circumference (WC) and waist-to-hip ratio (WHR) are the measurements most commonly used to estimate abdominal fat because they have a positive, significant correlation to the amount of intra-abdominal fat as assessed by imaging studies both in adults and children [21].

Waist circumference (WC) is a simple, easily available anthropometric measurement, giving relevant information about fat distribution and reflecting the degree of central adiposity in children.

Central obesity has been associated with the risk of cardiovascular and metabolic disease in children and anthropometric indices predictive of childhood central obesity include waist circumference (WC), waist-hip ratio (WHR) and waist-height ratio (WHtR)[22].

Recently, Xi et al. proposed international WC percentile cut-off points, specific for age and sex, to define central obesity based on data of 113,453 children and adolescents aged 4-20 years from eight countries in different regions (Bulgaria, China, Iran, Korea, Malaysia, Poland, Seychelles, and Switzerland) [23].

The 90th percentile was established as WC cut-offs to detect central obesity in this population, with good performance in predicting cardiovascular risk in normal weight children and was suggested to be used in the assessment of abdominal adiposity in children and adolescents in different countries.

First, the 90th percentile WC cutoff is also used by the IDF.The IDF recommended the 90th percentile WC cutoffs for defining central obesity for youth aged 6 to 15 years [14].

According to this recommendation we also chose the 90th WC percentile as the cutoff point to identify central obesity in children in our study.

Abdominal obesity in girls was registered in 12% for WC and 13.2% for WHR. In boys, abdominal obesity was found in 11% for WC and 10% for WHR. Our established percentile curves for WC and WHR are in line with previous studies in Bulgarian, Pakistan, Turkey, Chile, Venezuela etc.[8,21-26]

These cut-offs and curves can serve as valuable criteria for screening and identify children at a higher metabolic risk, for international comparisons and to better understand secular trends in paediatric obesity.

Conclusion

We have determined cut-off points from the 5th to the 95th percentile for anthropometric indices for commonly used to estimate overweight and obesity in school-aged children.

The present findings provide a tool that can be used in the clinical setting for the early detection and prevention of childhood obesity. Comparing the incidence of obesity in the world and in our country, we see that our country follows the trend of increasing obesity.

In order to prevent and reduce the increasing trend of obesity and its consequences, anthropometric variables of growth and nutritional status in children have to be constantly monitored.

The determination of central and general obesity assessment based on anthropometric measurements are still an important method of choice in clinical investigations.

Moreover, anthropometric measures are rapid, easy-to-perform, economic and are especially important for estimating obesity and children.

The presentation, therefore, in this study of waist circumference percentiles can help in further investigation of specific cut-offs in respect to certain metabolic complications of obesity in children.

References

1. Zafirova B, Todorovska L. Anthropometric parameters of growth and nutritional status in children aged 6 to 7 years in R. Macedonia. Adv med Sci 2009;54(20):289-95.
2. Fryar CD, Carroll MD, Afful J. Prevalence of overweight, obesity, and severe obesity among children and adolescents aged 2–19 years: United States, 1963–1965 through 2017–2018. NCHS Health E-Stats. 2020.
3. Lobstein T. Prevalence And Trends Across The World. In M.L. Frelut (Ed.), The ECOG's eBook on Child and Adolescent Obesity. 2015; Retrieved from ebook.ecog-obesity.eu
4. Valerio, G., Balsamo, A., Baroni, M.G. *et al*. Childhood obesity classification systems and cardiometabolic risk factors: a comparison of the Italian, World Health Organization and International Obesity Task Force references. Ital J Pediatr 2017; (43):19.
5. Zafirova B et all. Evaluation of Sex-Specific Differences of Anthropometric Variables That Were Used as Indicators of Nutritional Status in Macedonian Children. JMS. 2018; 1 (1): 25-30.
6. Chen, G., Yan, H., Hao, Y. et al. Comparison of various anthropometric indices in predicting abdominal obesity in Chinese children: a cross-sectional study. BMC Pediatr 2019; (19): 127.
7. World Health Organization [WHO]. (2017). Obesity and Overweight. Available at: http://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight
8. Avalos C, Díaz C, Martínez A, Bancalari R, Zamorano J, Harbin F, Cerda V, Fernández M, Cavada G, Arteaga J, Valenzuela M, Toro M, García H. Waist circumference percentiles in children and adolescents between 6 and 14 years from Santiago, Chile. Endocrinol Nutr. 2012; 59(5):296-303.
9. Kristen Cashin and Lesley Oot. Guide to anthropometry. A Practical Tool for Program Planners, Managers, and Implementers. 2018. https://www.fantaproject.org/sites/default/files/resources/FANTA-Anthropometry-Guide-May2018.pdf
10. California Department of Health Care Services, Systems of Care Division Child Health and Disability Prevention Program, Health Assessment Anthropometric mesaurements Guidelines Mar 2016 https://www.dhcs.ca.gov/services/chdp/Documents/HAG/4AnthropometricMeasure.pdf
11. de Onis M, Onyango AW, Borghi E, Nishida AS, Siekman J. Development of a WHO growth reference for school-aged children and adolescents. Bull WHO. 2007;85(9):649-732.
12. World Health Organisation. Obesity. In: World Health Organisation; 2016. http://www.who.int/topics/obesity/en.

13. Using the BMI-for-Age Growth Charts CDC https://www.cdc.gov/nccdphp/ dnpa/growthcharts/ training/modules/module1/text/module1print.pdf.
14. Zimmet P, Alberti G, Kaufman F, et al. ; International Diabetes Federation Task Force on Epidemiology and Prevention of Diabetes. The metabolic syndrome in children and adolescents. Lancet. 2007;369(9579):2059–2061.
15. Olcay Neyzi Ruvede Bundak Gublin Gokcay et all. Reference Values for Weight, Height, Head Circumference, and Body Mass Index in Turkish Children. J Clin Res Endocrinol 2015D; 7(4):280-293.
16. Vaman Khadilkar, Sangeeta Yadav et all. IAP Growth Charts for Height, Weight and Body Mass Index for 5- to 18-year-old Indian Children.Indian Pediatr 2015; 20 (52): 47-55.
17. CDC table for calculated BMI values for selected heights and weights for ages 2–20 years. National Health and Nutrition Examination Survey. 2000; Available from: http://www.cdc.gov/
18. Ma J, Wang Z, Song Y, Hu P, Zhang B. BMI percentile curves for Chinese children aged 7-18 years, in comparison with the WHO and the US Centers for Disease Control and Prevention references. Public Health Nutr. 2010 Dec;13(12):1990-6.
19. Body Composition in Children and Adolescents Residing in Southern Europe: Prevalence of Overweight and Obesity According to Different International References. Available from: https://www.researchgate.net/publication/330811755_Body_Composition_in_Children_and_Adolescents_Residing_in_Southern_Europe_Prevalence_of_Overweight_and_Obesity_According_to_Different_International_References
20. Cole TJ, Bellizzi CM, Flegal MK, Dietz HW. Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ. 2000;320:1240-6.
21. Unalan D, Senol V, Bayat M, Mazicioglu MM, Ozturk A, Kurtoglu S, Hatipoglu N, Ustunbas HB. Change in waist circumference over 3 years in Turkish children and adolescents. Ann Hum Biol. 2013 Sep-Oct;40(5):419-25.
22. Santos JLF, Valério VP, Fernandes RN, Duarte L, Assumpção AC, Guerreiro J, Sickler AL, Lemos ÁAR, Goulart Filho JG, Cesar LAM, Pinto IM, Magalhães C, Hussid MF, Camacho C, Avezum A, Sangaleti CT, Consolim-Colombo FM. Waist Circumference Percentiles and Cut-Off Values for Obesity in a Large Sample of Students from 6 To 10 Years Old Of The São Paulo State, Brazil. Arq Bras Cardiol. 2020 May-Jun;114(3):530-537.
23. Xi B, Zong X, Kelishadi R, Litwin M, Hong YM, Poh BK, Steffen LM, Galcheva SV, Herter-Aeberli I, Nawarycz T, Krzywińska-Wiewiorowska M, Khadilkar A, Schmidt MD, Neuhauser H, Schienkiewitz A, Kułaga Z, Kim HS, Stawińska-Witoszyńska B, Motlagh ME, Ruzita AT, Iotova VM, Grajda A, Ismail MN, Krzyżaniak A, Heshmat R, Stratev V, Różdżyńska-Świątkowska A, Ardalan G, Qorbani M, Świąder-Leśniak A, Ostrowska-Nawarycz L, Yotov Y, Ekbote V, Khadilkar V, Venn AJ, Dwyer T, Zhao M, Magnussen CG, Bovet P. International Waist Circumference Percentile Cutoffs for Central Obesity in Children and Adolescents Aged 6 to 18 Years. J Clin Endocrinol Metab. 2020 Apr 1;105(4):e1569–83.
24. Asif M, Aslam M, Altaf S, Mustafa S. Developing waist circumference, waist-to-height ratio percentile curves for Pakistani children and adolescents aged 2-18 years using Lambda-Mu-Sigma (LMS) method. J Pediatr Endocrinol Metab. 2020 Jul 6:/j/jpem.ahead-of-print/jpem-2019-0527/jpem-2019-0527.xml.
25. Poh BK, Jannah AN, Chong LK, Ruzita AT, Ismail MN, McCarthy D. Waist circumference percentile curves for Malaysian children and adolescents aged 6.0-16.9 years. Int J Pediatr Obes. 2011 Aug;6(3-4):229-35.
26. Mukherjee S, Leong HF, Wong XX. Waist circumference percentiles for Singaporean children and adolescents aged 6-17 years. Obes Res Clin Pract. 2016 Sep;10 Suppl 1:S17-S25.