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Çocuklarda Obezitenin Belirlenmesinde Antropometrik Ölçümlerin Karşılaştırılması: Sistematik Derleme

Comparing Anthropometric Measurements in Determining Obesity in Children: A Systematic Review

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ÖZ

Amaç: Güncel literatürde, çocuklarda obezitenin belirlenmesinde farklı ölçüm yöntemlerini ve farklı istatistiksel analizleri içeren çok sayıda çalışma mevcuttur. Bu çalışmanın amacı, çocuklarda obeziteyi ölçmek için kullanılan antropometrik ölçüm yöntemlerini derlemektir.

Yöntem: Çocuklarda obeziteyi ölçmek için kullanılan antropometrik ölçüm yöntemlerini araştıran çalışmalar üzerine sistematik bir derleme yapıldı. Pubmed/Medline ve Google Scholar veritabanları tarandı. Çalışmaların metodolojik kalitesi, Modifiye Downs and Black kontrol listesi kullanılarak incelenmiştir. Ardından önemli bulgular sentezlenmiştir.

Bulgular: 2006-2020 yılları arasında yayınlanan 24 çalışma derlemeye dahil edildi. Çalışmaların örneklem büyüklükleri 30 ile 23043 katılımcı arasında değişmekteydi. Katılımcıların yaş aralığı 2-18 yıldı. Çalışmaların %87,5'inde (n=21) ölçüm yöntemi olarak Vücut Kitle İndeksi (VKİ) kullanılmış ve VKİ ölçüm performansı diğer antropometrik ölçüm yöntemleriyle karşılaştırılmıştır. Bel çevresi (n=16), bel-kalça oranı (n=13) ve kol çevresi ölçümleri (n=8) en sık kullanılan yöntemler olmuştur.

Sonuç: Çocuk popülasyonunun obezite ve aşırı kiloluluk durumunu değerlendirmek için kullanılan antropometrik ölçümlerin karşılaştırılmasında VKİ skoru altın standart olarak görülmektedir. Bel çevresi ve bel-kalça oranı, Çift X-ışını Absorptiometri (DEXA) ve Hava Deplasmanlı Pletismografi (ADP) gibi daha doğru tekniklerin mümkün olmadığı çocuklarda obezite ve fazla kilonun ölçülmesinde en yaygın ve en etkin araçlardır.

Anahtar Kelimeler: Obezite, Antropometrik ölçümler, Bel çevresi, Bel-kalça oranı, Vücut kitle indeksi.

ABSTRACT

Objective: In the current literature, there are many studies that include different measurement methods and different statistical analyzes in determining obesity in children. The aim of this study is to review the anthropometric measurement methods used to measure obesity in children.

Method: A systematic review was completed for studies of anthropometric measurement methods used to measure obesity in children. The databases Pubmed/Medline and Google Scholar were searched. Methodological quality of studies was examined using the modified Downs and Black checklist. Subsequently, important findings were synthesized.

Results: Twenty four studies published between the years 2006-2020 were included in the review. Sample sizes varied between 30 and 23043 participants. The age range of the participants varied between 2-18 years. In 87.5% of the studies (n=21), Body Mass Index (BMI) was used as the measurement method and the performance of BMI was compared with other anthropometric measurement methods. Waist circumference (n=16), waist-hip ratio (n=13) and arm circumference measurements (n=8) are the most common used methods.

Conclusion: BMI score is seen as the gold standard in comparison of anthropometric measurements used to evaluate the obesity and overweight status of the child population. Waist circumference and waist-hip ratio are the most commonly used and effective tools for measuring obesity and overweight in children when more accurate techniques such as Dual X-ray Absorptiometry (DEXA) and Air-Displacement Plethysmography (ADP) are unfeasible.

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Key words: Obesity, Anthropometric measurements, Waist circumference, Waist-hip ratio, Body mass index.

1. INTRODUCTION

Obesity, which is an important risk factor for cardiovascular diseases, type-2 diabetes, hypertension and cancer, (1) increases the risk of these diseases in adulthood when it occurs in the early stages of life (2,3). Therefore, early assessment of nutritional status becomes important. Because, interventions that can prevent and control diseases associated with obesity and overweight are enabled.

There are various methods of measuring obesity in children. Among these, methods such as Dual X-ray Absorptiometry (DEXA) and Air-Displacement Plethysmography (ADP) are techniques that objectively measure body fat (4). In addition to these, epidemiological studies, skinfold measurements and bioelectric impedance are other methods used (5).

Anthropometric measurements are also a frequently used method in evaluating obesity. However, anthropometric measurements have a wide range. Waist circumference measurement, waist-hip ratio and Body Mass Index (BMI) are some of the methods included in this range.

Each measurement method has its own advantages and disadvantages. An ideal measurement method should be valid, reliable, easily applicable and cost-effective. For children, there are quite a few studies in the current literature involving different measurements and statistical analyzes. For this reason, it is necessary to determine the ideal anthropometric measurement method to be used to measure obesity in children. The aim of this study is to review the anthropometric measurement methods used to measure obesity in children.

2. METHOD

Various criteria were used when selecting the studies to be included in the review (Table-1). Children without age restriction were selected as the population to be searched in the studies. All anthropometric measurement methods were accepted as obesity measurement method. As statistical analysis methods, besides descriptive statistics and frequency analysis, correlation analysis, comparison analysis, chi-square analysis and regression analysis were chosen. The review has been kept up-to-date, including studies conducted in the last 15 years from January 2021. The languages included in the review were determined as Turkish and English languages in which the authors speak at an advanced level.

Bibliographic data were searched using PubMed/Medline and Google Scholar. A strategy was used to use phrases made up of relevant keywords during searches. Figure-1 shows an example of searches made through Google Scholar.

The studies to be included in the review were determined as a result of the unanimous decisions of the authors. While selecting the studies, a screening was made by first looking at their titles. Then, the abstracts of the studies were examined and their compliance with the inclusion criteria was questioned. The full text of the studies that passed this questioning was examined in terms of methodological quality. The methodological quality and risk of bias of eligible studies (n=72) were assessed with the Downs and Black checklist (6). The Downs and Black tool is a frequently used tool for methodological quality reviews. This tool, for which validity and reliability studies are available, is used to evaluate the methodological quality of the studies. There are items that can evaluate the problems that may affect the validity of the

reviewed studies. The original version consists of 27 questions. The first 26 questions are scored as 0-1-2, while the last question is scored as 0-1-2-3-4-5.

Table 1. Criteria for inclusion of studies

	Inclusion Criteria
Population	Whole child population without age restrictions
Obesity measurement methods	BMI, Waist circumference measurement, Waist-to-height ratio, Waist-to-hip ratio, Mid-upper arm circumference measurement, Arm-height ratio, Skinfold measurements, Neck circumference, Wrist circumference measurement, Conicity index, Waist circumference-height ratio in sitting position
Statistical analysis	Descriptive statistics, frequency analysis, correlation analysis, comparison analysis, chi-square analysis and regression analysis
Dates	Studies conducted between 2006-2020
Languages	English or Turkish

Search #	**Query**	**Number of Results**
1	"Child, children, adolescents, childhood" Filters: 2006 and beyond; English or Turkish	135.000
2	"BMI, Waist circumference measurement, Waist-height ratio, Waist-hip ratio, Mid-upper arm circumference measurement, Arm-height ratio, Skinfold measurements, Neck circumference measurement, Wrist circumference measurement, Conicity index, Waist circumference-height in sitting position" Filters: 2006 and after; English or Turkish	22.000
3	"Obesity, body fat, overweight" Filters: 2006 and after; English or Turkish	17.400
1+2+3	"Child, children, adolescents, childhood" AND "BMI, Waist circumference measurement, Waist-height ratio, Waist-hip ratio, Mid-upper arm circumference measurement, Arm-height ratio, Skinfold measurements, Neck circumference measurement, Wrist circumference measurement, taper index, waist circumference-height ratio in sitting position" AND "Obesity, body fat, overweight" Filters: 2006 and after; English or Turkish	3.140

Figure 1. An example of the strategy used during searches

Since the focus of our review was to compare studies examining anthropometric measurement tools used in determining obesity in children in terms of method, we preferred to use 11 items of the tool. The selected items were compatible with the methodology and the content of our study. We also set the cut-off score for methodological quality to be at least 9 points. It correspond to the third quarter of the total score.

Studies with good quality methodologies were included in the review (Figure-2). PRISMA guidelines were followed at all stages of this systematic review (7).

3. RESULTS

The methodological characteristics and main results of the studies included in our systematic review are given in Table 2. The studies published between 2006 and 2020 that selected the child population as a participant. Sample sizes varied between 30 and 23043 participants. The age range of the participants varied between 2-18 years.

Nine of the studies (37.6%) were in Asia, 8 (33.3%) in Europe, 3 (12.5%) in North America, 3 (12.5%) in South America and 1 (4.1%) was made in Africa.

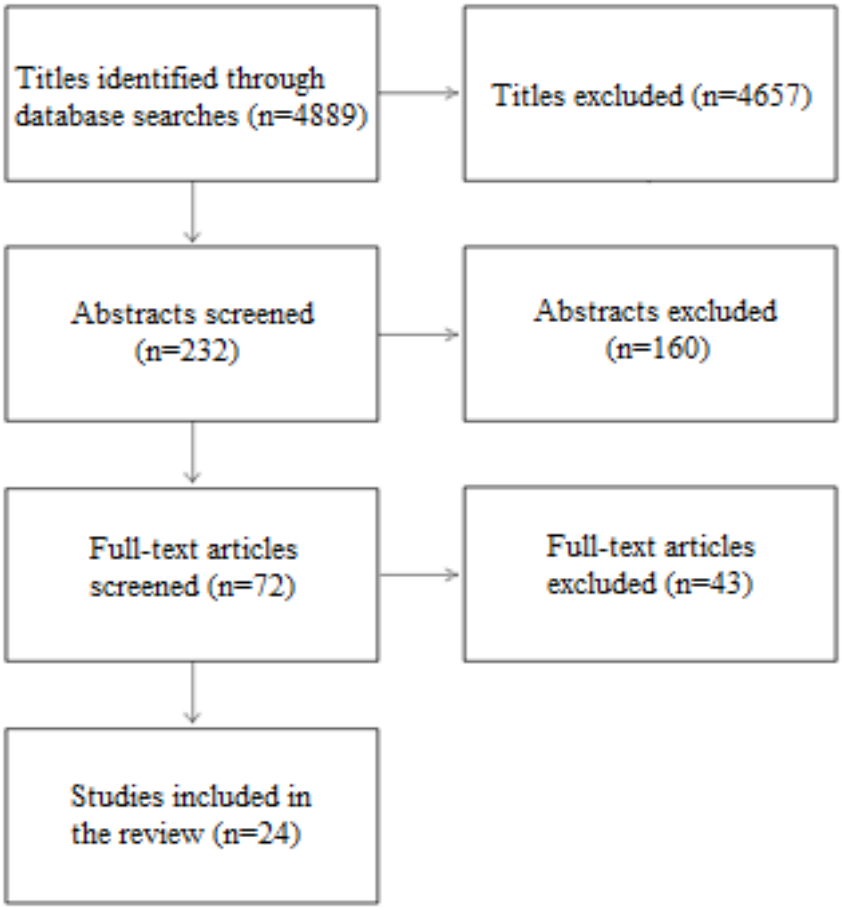

Figure-2. The scheme of selection of studies in this systematic review

In 87.5% of the studies (n=21), BMI was used as the measurement method and the performance of BMI was compared with other anthropometric measurement methods. Waist circumference (n=16), waist-hip ratio (n=13), arm circumference measurements in total (n=8), neck circumference (n=6), skinfold measurements (n=5), body fat measurements (n=4), hip circumference (n=3), waist-to-height ratio (n=3), conicity index (n=2), wrist circumference (n=1), leg circumference (n=1) and waist circumference-height ratio in sitting position (n=1) were used in the study.

Triceps were mostly preferred (n=5) in skinfold measurements. Triceps was followed by subscapular region (n=4).

In the studies, Receiver. Operating Characteristic (ROC) curves analysis was used with a rate of 58.3% (n=14). It is followed by correlation analysis (n=7) and comparison tests (n=7). Apart from these (n=1) regression analysis was used.

In the studies included in the review, the most frequently stated limitation (n=7) was the BMI's inability to measure the distribution of fat in the body, although it is accepted as the standard in diagnosing overweight (8). Another frequently stated limitation (n=5) is that BMI prevents a causal relationship between findings due to the cross-sectional study design. After that, it was shown as insufficient sample size (n=3) and bias (n=3) due to the intensive linear development due to puberty.

Table 2. The methodological characteristics and main results of the studies.

Authors (year)	Sample size (n) and population (age; country)	Methods	Test Statistics/Results
Shafiee et al, 2018 (9)	n=13486 Boys: 6840 Girls: 6640 6 to 18-year-old; Iran	wrist circumference, waist and hip circumference, BMI, waist-to-height ratio	Wrist circumference Overweight: AUC: 0.67–0.75 Obesity: AUC: 0.81–0.85 Abdominal Obesity: AUC: 0.82–0.87
Jayawardene et al, 2018 (9)	n=12269 12 to 18-year-old; USA	Arm Circumference-to-Height Ratio (AHtR), BMI	Female: AHtR ≥ 0.19 BMI percentile ≥ 94 Male: AHtR ≥ 0.16 BMI percentile ≥ 64 Probability of > 0.7 being unhealthy overall
Dumith et al, 2018 (10)	n=1075 Boys: 512 Girls: 513 13 to 19-year-old; Brazil	waist (WC), arm (AC) and leg (LC) circumference, waist/height ratio (WHR)	cut-off points for overweight: WC: 76.4 cm (boys), 74.6 cm (girls) AC: 26.4 cm (boys), 27.0 cm (girls) LC: 34.0 cm (boys), 34.5 cm (girls) WHR: 0.460 (boys), 0.475 (girls)
Asif, Aslam, and Altaf, 2018 (11)	n=5694 Boys: 2733 Girls: 2961 5 to 12-year-old; Pakistan	waist circumference (WC), waist-to-hip ratio (WHR), waist-to-height ratio (WHtR), conicity index (CI) and neck circumference (NC)	cut-off points for central obesity: WHtR: 0.47 cm (boys) 0.48 cm (girls) CI: 1.20 cm (boys) 1.23 cm (girls) WHR: 0.96 cm (both) NC: 26.36 cm (boys) 26.54 cm (girls)
Rerksuppaphol and Rerksuppaphol, 2017 (12)	n=3618 Boys: 1830 Girls: 1788 6 to 13-year-old; Thailand	MUAC, AhtR, BMI	MUAC-body weight r = 0.888 to 0.914 MUAC-BMI (r = 0.859 to 0.908) MUAC cut-off values for obesity (cm): 18.9-25.5 (boys), 19.8-25.4 (girls). AUC: 0.952–0.991 (boys), 0.917–0.990 (girls) AHtR cut-off values for obesity: 0.16 (both). AUC: 0.920-0.975 (both)

Table 2. The methodological characteristics and main results of the studies (continue).

Kondolot et al, 2017 (13)	n=1766 Boys: 874 Girls: 892 2 to 6-year-old; Turkey	NC, BMI	Mean increment for NC from 24 to 83 months (cm): 1.4 (boys), 0.5 (girls)
Zhu et al, 2016 (14)	n=2243 Boys: 1118 Girls: 1125 7 to 17-year-old; China	BMI, WC, WHR	BMI, WC and WHR have 65.1% accuracy for predicting disorders associated with dyslipidemic BMI has 77% accuracy for predicting disorders associated with dyslipidemic, while WHR has 70.8%.
Zhang et al, 2016 (15)	n=6889 Boys: 3438 Girls: 3451 7 to 17-year-old; China	Waist circumference (WC), waist-to-sitting-height ratio (WSHtR), BMI, triceps and subscapular skinfold	High WSHtR (≥75th) associated with overweight and obesity and high BP.
de Souza, Gurgel, de Carvalho Barreto, and Saravanan, 2016 (16)	n=1474 Boys: 658 Girls: 816 12 to 17-year-old; Brasil	Neck circumference (NC), waist circumference (WC), BMI	cut-off points for obesity by NC: 12 to 14 years (cm): 34.9 (boys), 33.85 (girls). 15 to 17 years (cm): 38.4 (boys), 35.85 (girls)
Kelishadi et al, 2016 (17)	n=23043 Boys:11706 Girls:11337 6 to 18-year-old; Iran	BMI, waist circumference (WC), waist to hip ratio (WHR); waist to height ratio (WtHR)	NC overweight AUC: 0.67 to 0.75. Obesity AUC: 0.81-0.85. Abdominal obesity AUC: 0.73-0.78.
Öztürk, Cicek, Mazicioglu, and Kurtoglu, 2015 (18)	n=5358 Boys: 2621 Girls: 2737 6 to 17-year-old; Turkey	WC, mid-upper arm circumference (MUAC), triceps skinfold thickness, BMI, fat percentages	Sleep duration (boys), maternal education (boys), using elevator (boys), and appetite (both) associated with abdominal obesity (binary multiple logistic regression analysis).
Katz et al, 2014 (19)	n=1913 Boys: 977 Girls: 936 6 to 17-year-old; Canada	NC, waist circumference (WC), BMI	Mean NC was 0.43-0.49 cm (females-males, for each BMI unit). Mean NC was 0.17-0.18 cm (females-males ,for each cm of WC)
Craig, Bland, Ndirangu, and Reilly, 2014 (20)	n=978 Boys: 474 Girls: 504 5 to 14-year-old; South Africa	MUAC, body fatness	10–14 years AUC: 0.97 (boys), 0.98 (girls)

Table 2. The methodological characteristics and main results of the studies (continue).

Candido, Freitas, and Machado-Coelho, 2011 (21)	n=788 Boys: 376 Girls: 412 6 to 15-year-old; Brasil	arm muscle area (AMA), arm fat area (AFA), Rohrer index (RI), conicity index (CI), and waist-to-height ratio (WtHR), BMI	Body fatness; Girls: r=0.80 to r=0.51. Boys: r=0.18 to r=0.69 RI has the highest sensitivity (87.5%) and specificity (98.7%). AFA and RI have high sensitivity (92.6%), CI is the most specific (93.7%) method.
Nafiu et al, 2010 (22)	n=1102 Boys: 573 Girls: 529 6 to 18-year-old; USA	Neck circumference (NC), waist circumference (WC), BMI	NC cutoff values: 28.5-39.0 cm for boys and 27.0-34.6 cm for girls.
Mazıcıoğlu et al, 2010 (23)	n=5358 Boys: 2621 Girls: 2737 6 to 17-year-old; Turkey	WC, MUAC, BMI	AUC values for WC and MUAC is not significant.
Atamtürk, 2010 (24)	n= 891 Boys: 445 Girls: 446 7 to 14-year-old; Turkey	mid-upper arm circumference, triceps and subscapular skinfolds, BMI	The ratios of obesity and overweight was 8%, 2%, %5 and 5% according to BMI, mid-upper arm circumference, triceps and subscapular skinfolds respectively.
Al-Daghri et al, 2010 (25)	n=964 Boys: 469 Girls: 495 5 to 17-year-old; Saudi Arabia	BMI, waist circumference, hip circumference, WHR	Cut-off points: Prepubertal 14 cm; pubertal 15-16 cm (girls-boys); postpubertal 21.5-22 cm (girls-boys)
Hubert, Guinhouya, Allard, and Durocher, 2009 (26)	n= 122 Boys: 65 Girls: 57 6.8 to 11.8-year-old; France	BMI, WC, WHtR; biceps, triceps, subscapular and suprailiac skinfolds	AUC ranged 0.80–1.00. WC and WHtR are more sensitive than BMI. The Youden Index is between 0.59–0.92 (gender) and 0.58–0.85 (maturation).
Davutoğlu et al, 2009 (27)	n=30 Boys: 16 Girls: 14 9 to 14-year-old; Turkey	waist circumference, hip circumference, BMI	Log visfatin has significant correlation with weight, waist circumference, hip circumference and BMI.
Yan et al, 2007 (28)	n=4186 Boys: 1977 Girls: 2209 8 to 18-year-old; China	WHTR, WC, BMI	Area under curve of WHTR is over 0.90 WHTR is better than waist circumference

Table 2. The methodological characteristics and main results of the studies (continue).

Semiz and Sabir, 2007 (29)	n=84 Boys: 46 Girls: 38 9 to 15-year-old; Turkey	BMI, waist circumference (WC), waist/hip ratio (WHR), triceps and subscapular skinfold thicknesses	BMI is the best single predictor of visceral (R^2: 0.53)
Yoo, Lee, Kim, and Sung, 2006 (30)	n=892 Boys: 438 Girls: 454 8 to 12-year-old; Korea	BMI, PWH, PBF	BMI and PWH: r=0.910 to 0.915
Tokmakidis, Christodoulos, and Mantzouranis, 2006 (31)	n=676 Boys: 327 Girls: 349 7 to 16-year-old; Greece	BMI	Prevalence estimates: overweight 23.1%; obesity 4.3%

AC: Arm Circumference **AhtR:** Arm Circumference-to-Height Ratio **AFA:** Arm Fat Area **AMA:** Arm Muscle Area **CI:** Conicity Index
LC: Leg Circumference **MUAC:** Mid-Upper Arm Circumference **NC:** Neck Circumference **PWH:** Percentage-Weight-for-Height
RI: Rohrer Index **WC:** Waist Circumference **WHR:** Waist/Height Ratio **WHtR:** Waist-to-Height-Ratio
WSHtR: Waist-to-Sitting-Height Ratio

4. DISCUSSION

When we look at the whole of our review study, more than thirty studies contributed significantly to the field, and we noticed that sometimes multidisciplinary studies were also conducted in different countries. In particular, the fact that the data covers different age groups and uses different methods may change the course of future studies. It is also very important that the studies conducted include samples between the ages of 2-18 and from different continents.

This systematic review review is based on the review of many studies on Body Mass Index (BMI). The advantages of BMI examination studies to the scientific world, the results of the statistical data obtained and the ease of obtaining them, being harmless, and open source of the data are also suitable for epidemiological studies.

In the study conducted by Craig et al. in 2014, it was aimed to calculate the weight and obesity in rural South African children and adolescents, especially in the upper and forearm regions (20). They analyzed data such as weight, height, and fatness obtained by anthropometric methods from 978 black South African people aged 5-14. The obesity ROC-AUC values of boys and girls aged 10-14 were given as 0.97 and 0.98, respectively. While obesity and obesity were determined in boys, sensitivity and specificity were determined in girls between the ages of 5-9 and 10-14. While obesity is common in children as in the world, we can say that economic conditions in South Africa are effective in obesity in children. This rate fluctuates especially in underdeveloped societies (20).

In the study of Sardinha et al. in 1999, it has been observed that valid and practical methods and general criteria for obesity screening in children and adolescents are not available. Adolescents at high risk should be selected in body mass index (BMI) studies (32). The aim was to observe the development of obesity in adults. The aim of their study was to measure obesity levels by measuring BMI values from the thickness of the triceps skin fold around the upper arm. A cross-sectional study of 165 boys and 163 girls, aged 10-15, Portuguese. Body fat ratio of 25% in boys has been measured as 30% in girls. ROC analysis was used to define nonparametric data as well. Actual positivity rates vary between 67% and 87%. For children aged 10-11 years, the areas under the curves (AUCs) were found with the diagnostic accuracy index ROCs close to 1.0. Triceps skinfold thickness ratios, which give better values in adults, were also compared. The data obtained from this study also show that these rates, which are close in girls and boys, are more common in girls who enter adolescence faster and have a relatively higher rate of fatness than boys. This situation is in accordance with the general perspective and is the results that both Physical Anthropologists and researchers working in the field of Physical Therapy and Rehabilitation frequently encounter in terms of average values in terms of geographical location, socio-economic level and development of the society (32).

Hubert et al.'s study, it was aimed to determine the optimum relationship between obesity and neck circumference depending on gender and age (26). The sample of this study on weight problems in Iranian children was limited to 6-18 years old. This nationwide study was conducted with over twenty-three thousand of students. The mean age was 12.55 years and the difference between genders was 3.31 years. According to the results of anthropometric measurements, it can be said that abdominal obesity is seen. Studies conducted by countries on immigrants and refugees will contribute to secular trend studies in the future (26).

In the study conducted by Zhang et al in China, waist circumference measurements were taken and abdominal obesity was measured with relevant anthropometric indices (15). However, it was also emphasized that little is known about the ratio of waist-sitting height and its relationship, and whether obesity and high blood pressure are effective. In this study, 6889 students (3438 boys and 3451 girls) of school age children aged 7-17 were included. Subscapula and triceps skinfold measurements, height-weight measurements in the height-sitting position and blood pressure measurements of all participants were made. The standard cut-off scores of BMI were used to determine obesity. They revealed that the effects of both gender and age on blood pressure and obesity are different with the data they obtained. These studies need to be done in other geographies and with more participants. Because obesity has become the new plague of the age and obesity issue is more important in children (15).

In Rerksuppaphol's study in 2017, he looked at Body Mass Index (BMI) through anthropometric parameters to detect obesity in children (12). For this purpose, the mid-upper arm circumference and the mid-upper arm circumference ratio were compared. BMI has been studied in school-age children and revealed this as an observational-cross-sectional study. The study included children from grade 1 to grade 6 in public primary schools of low-income families in rural areas in Nakhon and Nayok districts in Ongkharak county, Thailand. Data from 3.618 children aged 6 to 13 years were analyzed. The data obtained also showed that the fat in girls is slightly higher and this is what is expected. Interpretation of the data obtained by anthropometric measurements is one of the methods frequently used by scientists (12).

Dumtih et al. in the study he conducted in 2018, waist and arm circumference measurements were taken from 1075 young people between the ages of 13-19 in Brazil (10). Z-score and Body Mass Index (BMI) were examined in determining obesity according to the World Health Organization criteria. Anthropometric data obtained from adolescents living in the semi-arid region of Brazil showed that climate and geography are important in BMI studies. Regional characteristics should also be taken into account in studies to be conducted with adolescents (10).

5. CONCLUSION

In conclusion, according to our review, BMI score is seen as the gold standard in comparison of anthropometric measurements used to evaluate the obesity and overweight status of the child population in the current literature. In addition, waist circumference and waist-hip ratio are the most commonly used measurements, and they are also effective tools for measuring obesity and overweight in children when more accurate techniques such as DEXA and ADP are unfeasible. Our review also showed that anthropometric measurements are safe, valid, easy and low-cost methods that can be used in the pediatric population.

Conflict of interest statement

The authors declare no conflicts of interest.

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