COMPARISON BETWEEN WAIST CIRCUMFERENCE-TO-HEIGHT RATIO AND BODY MASS INDEX TO PREDICT ADIPOSITY IN SCH OOL AGED CHILDREN FROM 5 TO 15 YEARS

By

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ABSTRACT

Introduction*: obesity is defined as a situation by which there is excess body fat leading to health impairment and waist circumference-to height ratio (WHtR) is a simple, easy, inexpensive, highly reproducible and accurate tool for prevention , control, and intervention against child hood obesity.*

Aim of the Work*: comparison between Waist circumference-to- Height Ratio (WHtR) and Body Mass Index (BMI) for prediction of overweight and obesity in school children aged 5 - 15 years.*

Patients and Methods: *A cross-sectional study was conducted on a sample of 1000 students who attended government schools conducted in the village "Qai" which is a rural area in Beni-Suef governorate. , during the first and the second school trimester between December 2017 and May 2018. Both sexes were included.*

Results: *in the present study, 1000 students, consisted of 506 female(50.6%) and 494 male(49.4%) with mean age ± SD 9.58 ± 2.24 years (range 5.1 – 15 years) and the overall prevalence of overweight and obesity according to BMI percentile was 34.6%, The overall prevalence of overweight was 17.7% more in girls than boys (9.6 % girls and 8.1% boys) and that of obesity was 16.9% more in girls than boys (9.7 % girls and 7.2 % boys) and hyperlipidemia in obese children was 32% , 7.7% of them had combined Hyperlipidemia, 14.2 % had hypertriglyceridemia & 10.1% had Hypercholesterolemia . the WHtR & BMI were highly sensitive as an indicator of adiposity, but WHtR was highly sensitive than BMI as WHtR showed that (Area Under Curve (AUC) = 0.986, sensitivity =94.87%, & specificity = 93.64 %) according to the Receiver Operating Characteristic (ROC) curve analysis for obese cases from normal with cut-off point > 0.47 for both sexes, and BMI showed that (AUC = 0.935, sensitivity = 85.13%, & specificity = 87.3%).*

Conclusion: *The prevalence of overweight and obesity is considerably high in Egyptian children and was more in girls than in boys and hyperlipidemia in obese children was found in 32% of obese children and WHtR & BMI are highly accurate indicators of adiposity in Egyptian school children . Our findings suggest that the WHtR is useful index for school screening and is particularly useful and superior on BMI and not dependent on Age & sex and is easier to use.*

Recommendations: *We believe that the WHtR should become a routine measurement in Egyptian school children to predict childhood adiposity to deal with it and further studies are required to validate cutoff values and the effectiveness of WHtR as anthropometric index to predict childhood adiposity.*

Key Words: *obesity, Waist Circumference-to-Height Ratio and Body Mass Index.*

INTRODUCTION

Worldwide raising trend in obesity among children causing serious public health concerns and in developing countries it is threatening the viability of basic health care delivery. Many systemic co-morbid conditions like cardiovascular, orthopedic, neurological, hepatic, pulmonary and renal disorders are seen in association with childhood obesity **(Singh et al, 2008)**.

Overweight and obesity in childhood have significant impact on both physical and psychological health; for example, overweight and obesity are associated with hyperlipidemia, hypertension, and infertility. In addition, psychological disorders such as depression occur with an increased frequency in obese children **(Daniels et al, 2005)**.

BMI is in fact not able to disentangle fat- and fat-free tissues, and does not take into account body fat distribution, which may be more important than total adiposity as risk factor for cardio-metabolic diseases **(McCarthy et ah , 2006)**.

Waist circumference (WC) and waist circumference-to height ratio (WHtR) have been proposed as markers of adiposity related morbidity **(McCarthy et al, 2006)**.

The waist circumference-to height ratio (WHtR) is superior to BMI and waist circumference (WC) alone as marker of total and trunk adiposity, and is a good marker of body adiposity **(Brambilla et al, 2013)**.

The waist circumference to height ratio (WHtR) is of great value in screening populations at high risk for abdominal obesity and cardiovascular diseases and predicting the risk for cardiovascular diseases **(Shen et al, 2017)**.

PATIENT AND METHODS

Methodology:

This descriptive cross-sectional study was conducted in the village "Qai" which is a rural area in Beni- Suef governorate.

A cross-sectional study was conducted on a sample of students The study included 1000 students, who attended government schools (Qai primary schools,4 schools, & almahd aldini in "Qai" &Qai preparatory school) during the first and the second school trimester between December 2017 and May 2018. Both sexes were included.

Ethical consideration:

- Well-informed verbal and written consents were obtained from one of the parents for every student before the study.
- Approval of the local ethical committee in the pediatrics department, college and university were obtained before the study.
- Written consents were obtained from the Sector of Al Azhar Institutes and the school directors in Beni-Suef Governorate.
- The authors declared no potential conflict of interest with respect to the research & publication of this article.
- All the data of the patient & results of the study are confidential & the student has the right to keep it.
- The authors received no financial support for the research & publications of the article.

CRITERIA OF STUDY

Inclusion criteria:

- Healthy School children between age group of 5-15 years.

Exclusion criteria:

- Students younger than 5 or older than 15 years were excluded.
- Children suffering from chronic illness.
- Children on long term medications as corticosteroids.
- Children with congenital anomalies.

Anthropometric measurements:

The different anthropometric measurements in the class room after instructing the students to take off heavy clothes, shoes and belts, including:

● **Weight (Wt):**

Weight was measured using a digital portable scale that measuring to nearest 0.5 kilogram (kg) and with capacity of 150 kg.

This scale was standardized daily by using a standard five kg weight.

● Height (Ht):

Suitable metallic meter scale measuring to the nearest 0.5 cm, fixed to the vertical wall was used. I measured the heights of the subjects without shoes, taking into account that heals, buttocks, shoulders and head were contacting the wall surface. A ruler was used horizontally to determine the height.

■ Body mass index (BMI):

It equals weight (Wt) in kilograms (kg) over height (Ht) in meters square (m2) (BMI = Wt ÷ Ht2) **(WHO, 2000)**.

Cut off point for BMI:

For children and adolescents (aged 2-19 years), obesity is defined as a BMI at or above the 95th percentile for children of the same age and sex. Overweight is defined as a BMI at or above the 85th percentile and lower than the 95th percentile **(CDC, 2009)**.

■ Triceps skinfold thickness (TSFT):

Was measured on the midline of the back of the arm at the mid-point level between the acromion process and the tip of the olecranon process by using skinfold thickness caliper and each TSFT was measured three times and the average of the three measurements was used **(Kuhle et al, 2016)**.

Cut off point for TSFT:

For children and adolescents (aged 1.5-19 years), obesity is defined as a TSFT at or above the 95th percentile for children of the same age and sex. Overweight is defined as a TSFT at or above the 85th percentile and lower than the 95th percentile **(Addo & Himes, 2010)**.

■ Waist circumference:

Waist circumference was measured at the midpoint between the lower edge of the rib cage and the iliac crest **(Yang et al., 2017)**.

■ Waist circumference to Height Ratio (WHtR):

Was measured as waist circumference (cm) divided by height (cm) (WC÷ Ht) **(Yang et al., 2017)**.

Cut off point for WHtR:

The value of 0.50 for the WHR has been established as the suitable cut off for obesity for both adults and children **(Brannsether et al, 2011) (Mushtaq et al, 2011) (Khoury et al, 2016)**.

Biochemical tests:

All obese students underwent a comprehensive biochemical test, including lipid profiles measurements. Twelve-hour fasting blood samples were collected for the determination of plasma lipids by auto-analyzer (Sunostik SBA-733 plus): Triglyceride (TG), total cholesterol (TC), High- density lipoprotein (HDL), and low-density lipoprotein (LDL) for obese children.

Statistical Analysis:

In the statistical comparison between the different groups, the significance of difference was tested using one of the following tests:-

1. ANOVA (analysis of variance):- Used to compare between more than two groups of numerical (parametric) data and post-hoc analysis was used to detect significance difference between every two groups.
2. Inter-group comparison of categorical data was performed by using chi square test (X2-value).
3. Parameters were entered into regression model to determine which of these factors is considered as a significant risk predictor:

A P value <0.05 was considered statistically significant (S) and a P value <0.01 was considered highly significant (HS) in all analyses.

4. Receiver operating characteristic (ROC) curves used for comparison between groups by Area under curve ,sensitivity and specificity and determined the Cut-off values by using the point on the ROC curve with the lowest value for the formula $(1 - \text{sensitivity})^2 + (1 - \text{specificity})^2$.

RESULTS

Table (1): Age and gender distribution among the studied group

		Total no. = 1000
Age (years)	Mean ± SD	9.58 ± 2.24
	Range	5.1 – 15
Sex	Female	506 (50.6%)
	Male	494 (49.4%)

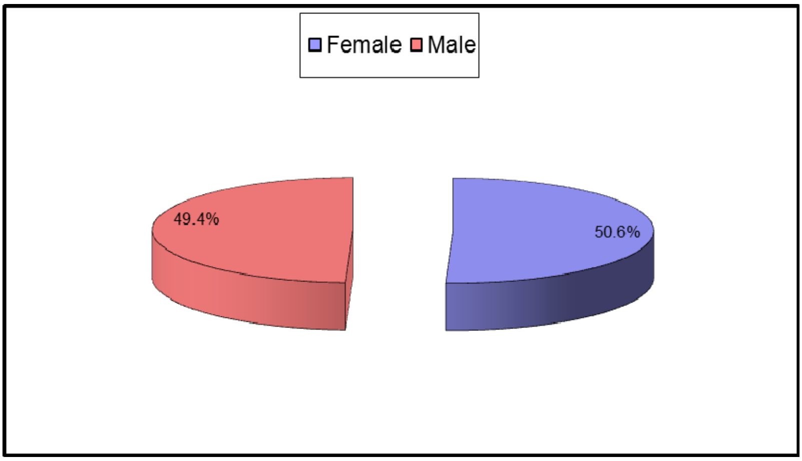


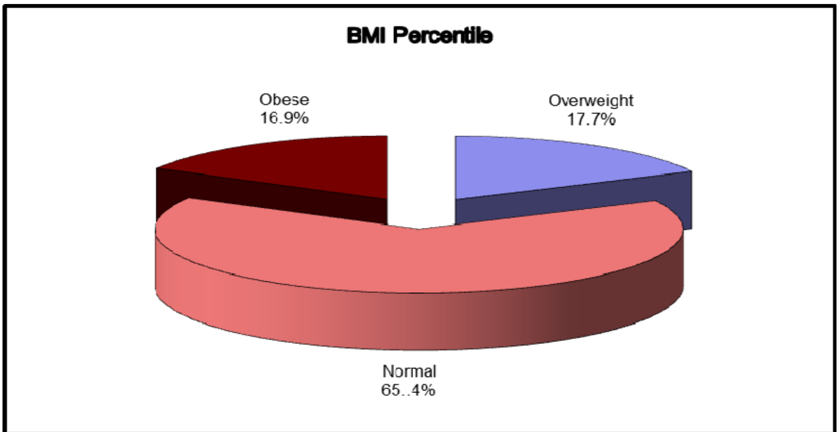
Figure (1):

Table (1) & figure (1): A total of 1000 children participated in the study, of whom 506 (50.6%) were female and 494 (49.4%) were male and range of Age from 5.1 to 15 years old with mean age of 9.58 (± 2.24) years.

Table (2): Distribution of studied children according to anthropometric measurements:

		Total no. = 1000
Wt (kg)	Mean ± SD	33.46 ± 12.51
	Range	14 – 91
Ht (cm)	Mean ± SD	133.04 ± 14.49
	Range	98 – 178
WC (cm)	Mean ± SD	62.09 ± 19.32

	Range	41 – 595



WHtR	Mean ± SD	0.46 ± 0.05
	Range	0.28 – 0.67
BMI (kg/m²)	Mean ± SD	18.64 ± 7.48
	Range	11.1 – 178
BMI Percentile	Normal	654 (65.4%)
	Overweight	177 (17.7%)
	Obese	169 (16.9%)
TSFT (mm)	Mean ± SD	14.93 ± 5.28
	Range	7 – 31.5
TSFT percentile	Normal	660 (66.0%)
	Overweight	145 (14.5%)
	Obese	195 (19.5%)

Figure (2):

Table (2) & figure (2): show that 16.9% of the study's children were obese, 17.7% were overweight and that the remaining 65.4% were of normal body weight or underweight according to CDC cut off point for BMI.

Table (3): Correlation between BMI & Age & Sex

		Normal weight group	Overweight group	Obese group	Test value	P-value	Sig.
		No. = 654	No. = 177	No. = 169			
Age	Mean ± SD	9.55 ± 2.14	9.12 ± 2.10	10.15 ± 2.59	9.515•	<0.001	HS
	Range	5.1 – 14.8	5.6 – 15	6.1 – 15			
Sex	Female	313 (31.3%)	96 (9.6%)	97 (9.7%)	6.025*	0.049	S
	Male	341 (34.1%)	81 (8.1%)	72 (7.2%)			

P-value > 0.05: Non-significant; P-value < 0.05: Significant; P-value < 0.01: Highly significant
*: Chi-square test; •: One Way ANOVA test.

This table shows that the prevalence of overweight and obesity was more in girls than boys and in older Age than younger in obese children but overweight in younger Age than older Age that the difference was statistically significant with Sex and highly significant with Age.

Table (4): Lipid profile in Obese Children

		Total no. = 169
Cholesterol (mg/dl)	Mean ± SD	178.06 ± 25.32
	Range	39 – 250
Triglyceride (mg/dl)	Mean ± SD	107.61 ± 28.12
	Range	60 – 180
LDL(mg/dl)	Mean ± SD	93.91 ± 25.91
	Range	51.1 – 175.4
HDL(mg/dl)	Mean ± SD	63.09 ± 9.66

	Range	11 – 80
Hyperlipidemia	Normal	115 (68.0%)
	Hypercholesterolemia	17 (10.1%)
	Combined hyperlipidemia	13 (7.7%)
	Hypertriglyceridemia	24 (14.2%)

Figure (3):

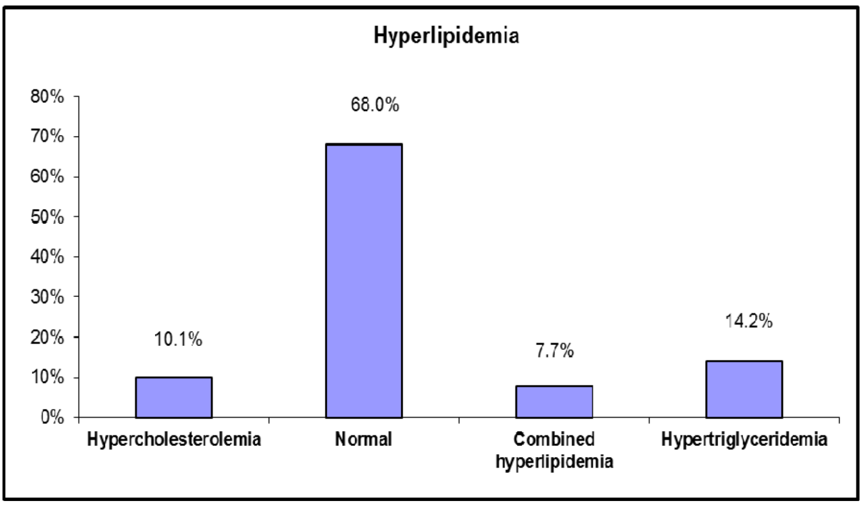


Table (4) & figure (3): show that 32 % of the obese children had Hyperlipidemia, 7.7% of them had combined Hyperlipidemia, 14.2 % had hypertriglyceridemia, 10.1 % Hypercholesterolemia and the remaining 68% were normal.

Table (5): Correlation between WHtR and anthropometric measurements

	WHtR	
	r	**P-value**
Age	0.018	0.566
WT	0.236**	< 0.001
HT	-0.084**	0.008
WC	0.547**	< 0.001
BMI	0.637**	< 0.001
TSFT	0.747**	< 0.001

P-value > 0.05: Non-significant; P-value < 0.05: Significant; P-value < 0.01: Highly significant.
Spearman correlation coefficient.

Table (5): show that correlation of WHtR with Wt, Ht, WC, BMI&TSFT are highly significant (P-value < 0.01), but with age Non-significant (P-value > 0.05).

Table (6): Correlation between WHtR and sex

Sex	WHtR		Test value••	P-value	Sig.
	Mean ± SD	**Range**			
Female	0.46 ± 0.05	0.30 – 0.64	-0.853	0.394	NS
Male	0.46 ± 0.04	0.28 – 0.67			

P-value > 0.05: Non significant; P-value < 0.05: Significant; P-value < 0.01: Highly significant
••: Independent t-test

This table shows that correlation of WHtR with sex is Non-significant (P-value > 0.05).

Figure (4): Receiver operating characteristic (ROC) curve for prediction of overweight cases

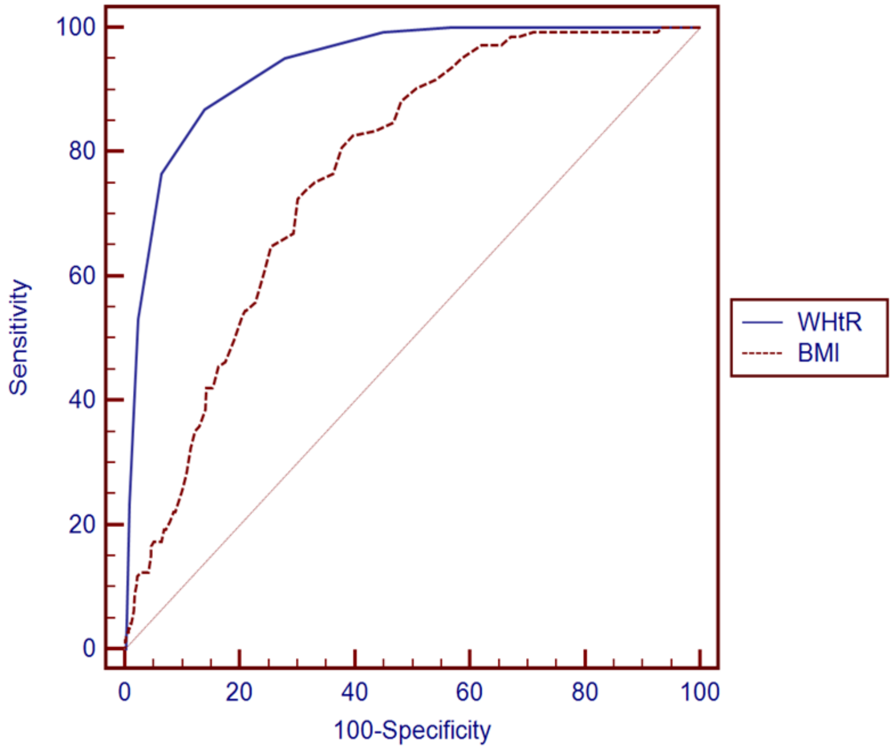


Table (7):

	Cut off point	AUC	Sensitivity	Specificity	+PV	-PV
WHtR	>0.46	0.938	86.9	86.1	57.8	96.8
BMI	>17.1	0.768	82.8	60.3	31.4	94.1

Figure (4) & table (7): Show that Receiver Operating Characteristic (ROC) curve analysis, Area under curve (AUC), sensitivity and specificity of WHtR & BMI for overweight cases, and AUC, specificity and sensitivity are higher in WHtR than BMI

Figure (5): ROC curve of predicting obese cases

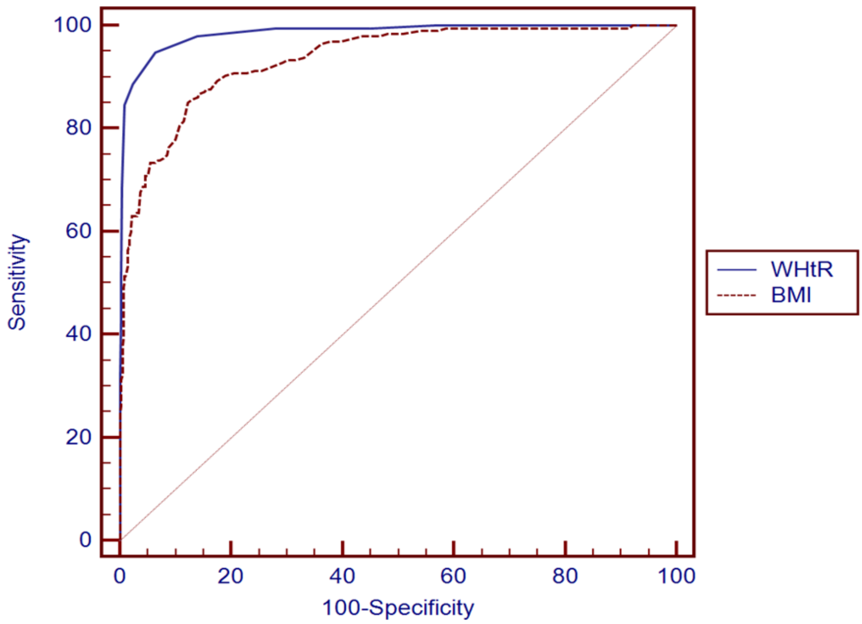


Table (8):

	Cut off point	AUC	Sensitivity	Specificity	+PV	-PV
WHtR	>47	0.986	94.87	93.64	81.5	98.4
BMI	>19.1	0.935	85.13	87.73	67.2	95.2

Figure (5) & table (8): Show that Receiver Operating Characteristic (ROC) curve analysis, Area under curve (AUC), sensitivity and specificity of WHtR & BMI for obese cases, and AUC, specificity and sensitivity are higher in WHtR than BMI.

DISCUSSION

Obesity is a state in which there is excess body fat leading to health impairment. It is primarily due to an imbalance between energy intake and energy expenditure usually resulting from increased food intake and/or decreased physical activity **(Dehghan et al., 2005)**.

Overweight and obesity in childhood have significant impact on both physical and psychological health; for example, overweight and obesity are associated with hyperlipidemia, hypertension, abnormal glucose tolerance, and infertility. In addition, psychological disorders such as depression occur with an increased frequency in obese children **(Daniels et al, 2005)**.

Therefore, our study intended to estimate the prevalence of overweight and obesity among 5-15 years old Egyptian children in rural area.

In our study 1000 students were included and consisted of 506 female (50.6%) and 494 male (49.4%) with mean age ± SD 9.58 ± 2.24 years (range 5.1 – 15 years).

In our study, we found that the overall prevalence of overweight and obesity according BMI was 34.6%. The overall prevalence of overweight was 17.7% (9.6% girls and 8.1% boys) and that of obesity was 16.9% (9.7% girls and 7.2% boys).

In **(Hadhood et al., 2017)** studied on School Children in Sohag, Egypt, 711 children, 117 (16.5%) were overweight and 104 (14.6%) were obese.

In our study, we found that prevalence of hyperlipidemia in obese children was 32% of the obese children had Hyperlipidemia, 7.7% of them were had combined Hyperlipidemia, 14.2 % were had hypertriglyceridemia, 10.1% Hypercholesterolemia and the remaining 68% were normal.

In **(Casavalle et al., 2014)** study, the prevalence of dyslipidemia among overweight and obese children was 50.4% and its pattern was: hypertriglyceridemia 31.9%, low HDL-C 29.7%, high non-HDL-C 15.8%, hypercholesterolemia 11.9%, and elevated LDL-C 10.7%.

There is studies concluded that WHtR is better than BMI in predicting total adiposity in children. Those studies were conducted with data from the US-NHANES in 2003–2004 and 2001–2004 respectively, and thus they had an overlap of data that could explain their agreement. Both studies had several strengths, such as large sample sizes (N = 2239 and N = 5355 respectively), wide age ranges of participants (8–18 and 8–19 respectively), and multi-ethnicity. **(Brambilla et al., 2013)** reported a multivariable adjusted model including age, sex, and race, and **(Tuan & wang, 2014)** stratified the results by sex and ethnicity-race. Nevertheless, their results may be limited due to a suboptimal adjustment for potential confounders (Tanner stage) and a lack of tests for interaction.

Prospective studies and meta-analyses of adults have revealed that the WHtR is equivalent to or slightly better than WC and superior to BMI in predicting higher cardiometabolic risk. Studies in children and adolescents showed that WHtR is similar to both BMI and WC for identifying those with increased cardiometabolic risk. Additional large-scale prospective studies are needed to confirm the usefulness of WHtR for predicting comorbidities of obesity in children and adolescents **(Yoo, 2016)**.

This study to demonstrate the validity of WHtR as identifiers of adiposity for population-based screening in Egyptian school children.

The choice of skinfolds as the method of comparison, rather than such techniques as DEXA or ADP, enabled measurements to be taken in the school itself, facilitating the field work. The literature indicates this method as the best choice when DEXA or ADP equipment is not available **(Jensen et al, 2016)**.

In our study, we used TSFT as a gold standard due to DEXA which is the best gold standard for prediction of body fat distribution and adiposity not available in Egypt and highly expensive.

In our study, WHtR was a non-significant difference regarding Age & Sex.

In our study, WHtR & BMI were highly sensitive as an indicator of adiposity, but WHtR was highly sensitive than BMI. WHtR showed that (AUC = 0.986, sensitivity = 94.87%, specificity = 93.64 %) according to the Receiver Operating Characteristic (ROC) curve analysis for obese cases from normal with cut-off point> 0.47 for both sexes, and BMI showed that (AUC = 0.935, sensitivity = 85.13%, specificity = 87.3%) .

In **(Bacopoulou et al., 2015)** WHtR was a better predictor for general obesity in both boys and girls (AUC 95% CI 0.945-0.992) than the waist to hip ratio (WHR) (AUC 95% CI 0.758-0.870); the WHtR cut-off of 0.5 had sensitivity 91% and specificity 95% for both genders and all age groups combined.

On the other hand, **(Barreira et al., 2014)** was found that BMI explained a greater percentage of the BF than the WHtR in a similar multiracial and wide age-range sample. No significant interactions were observed. Similar results were reported by **(Karlsson et al., 2013)**.

The high AUCs obtained by ROC curve analysis indicated the high validity of this anthropometric measure, WHtR, in distinguishing excess fat from a normal level of fat especially in older children.

CONCLUSION

The prevalence of overweight and obesity is considerably high in Egyptian children and was more in girls than in boys and hyperlipidemia in obese children was found in 32% of obese children and WHtR & BMI are highly accurate indicators of adiposity in Egyptian school children . Our findings suggest that the WHtR is useful index for school screening and is particularly useful and superior on BMI and not dependent on Age & sex and is easier to use.

RECOMMENDATIONS

1- Pediatric primary care providers need to pay much more care for managing chronic diseases such as obesity. More health care practitioners with expertise in obesity treatment, a staged approach to obesity treatment services and additional tertiary care centers are necessary.

2- Further studies are required to validate cutoff values and the effectiveness of WHtR as anthropometric index to predict childhood adiposity.

3- We believe that the WHtR should become a routine measurement in Egyptian school children to predict childhood adiposity and to deal with it.

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مقارنة بين محيط الخصر إلى نسبة ارتفاع الجسم و معدل كتلة الجسم لتحديد البدانة في أطفال المدارس الذين تتراوح أعمارهم بين 5- 15 سنة

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لا يزال انتشار البدانة لدى الأطفال في تزايد في جميع أنحاء العالم . لذلك ، أصبح وباء السمنة في العقد الماضي الشاغل الأول للمنظمات الصحية الزيادة.

كما أن الوزن الزائد والسمنة في مرحلة الطفولة لها تأثير كبير على الصحة الجسدية والنفسية فعلى سبيل المثال ، يرتبط الوزن الزائد والسمنة مع ارتفاع الدهون في الدم، وارتفاع ضغط الدم ، وأمراض القلب والأوعية الدموية ، مرض السكرغير المعتمد على الإنسولين ، توقف التنفس أثناء النوم ، والكبد الدهني والعقم ، بالإضافة إلى أن السمنة تحدث اضطرابات نفسيّة مثل الإكتئاب.

الهدف من هذه الدراسة:

المقارنة بين محيط الخصر إلى نسبة ارتفاع الجسم ومعدل كتلة الجسم لتحديد البدانة في أطفال المدارس الذين تتراوح أعمارهم بين 5-15 سنوات.

المرضى وطرق البحث:

اشـــتملت الدراســـة علـــى 1000 طالـــب مـــن الجنســـين مـــن طـــلاب المـــدارس الحكوميـــة فـــي قريـــة "قـــاي" وهـــي منطقـــة ريفيـــة فـــي محافظـــة بنـــي ســـويف، خـــلال الفصـــل الدراســـي الأول والثـــاني في الفترة ما بين ديسمبر 2017 وأيار 2018.

نتائج الدراسة:

إن انتشـــار فـــرط الـــوزن والبدانـــة مرتفـــع بشـــكل كبيـــر فـــي الأطفـــال المصـــريين وكـــان أكثـــر فـــي الفتيـــات منـــه فـــي الأولاد وفـــرط شـــحميات الـــدم لـــدى الأطفـــال البـــدناء وجـــد فـــي 32٪ مـــن الأطفـــال البـــدناء كمـــا أن محـــيط الخصـــر إلـــى نســـبة ارتفـــاع الجســـم، و معـــدل كتلـــة الجســـم هـــي مؤشـــرات دقيقـــة للغايـــة لقيـــاس البدانـــة لـــدى أطفـــال المـــدارس المصـــرية ، و تشـــير النتـــائج التـــي توصـــلنا إليهـــا إلـــى أن مؤشـــر محـــيط الخصـــر إلـــى نســـبة ارتفـــاع الجســـم هـــو مؤشـــر مفيـــد للفحـــص المدرســـي وهـــو مفيـــد بشـــكل خـــاص ومتفـــوق علـــى مؤشـــر معـــدل كتلـــة الجســـم ولا يعتمـــد علـــى العمـــر والجـــنس وهو أسهل في الاستخدام.