Original Article

Comparison of selected body composition parameters in women using DXA and anthropometric method

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Background: An excessive accumulation of the adipose tissue in women's organism is a frequent and important medical problem which should be monitored. The aim of this study was to explore correlations between the selected parameters of body composition assessed using DXA and anthropometric methods. **Materials and Methods:** The study group consisted of 50 women aged 51–85. Both adipose mass and fat-free mass were assessed with the DXA method, and the nutritional status of the participants was evaluated with the anthropometric methods. **Results:** The mean body mass index (BMI) value assessed with the DXA method amounted to 28.4 (±5.12). The Spearman's Rho correlation indicated the presence of a moderate association (0.27–0.50) between: (1) right arm lean and the circumference of the arm ($P = 0.020$), forearm ($P = 0.011$), and transverse cross-section of the arm ($P = 0.020$), (2) right leg fat and circumference of the thigh ($P = 0.003$), shin ($P = 0.009$), and also the musculature index of the lower extremity ($P = 0.034$), (3) visceral adipose tissue (VAT) mass and BMI ($P = 0.050$), Waist to HeightRatio (WtHR) ($P = 0.031$), (4) Android fat and WHtR ($P = 0.044$), and (5) gynoid fat and Škerlj index ($P = 0.025$). **Conclusion:** The selected parameters assessed with DXA were significantly correlated with the selected parameters assessed with anthropometric methods. WHtR anthropometric parameter is significantly correlated with DXA parameters: VAT mass, gynoid region % fat and android region % fat.

Key words: Anthropometry, body composition, dual energy X-ray absorptiometry, women

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INTRODUCTION

Excessive accumulation of adipose tissue is a frequent and important medical problem.[1,2] In 2011, in Poland, 46.2% of women and 63.6% of men were characterized by excessive body weight, and the prevalence of excessive body fat and metabolic syndrome increased with age.[3] The relationship between obesity, excessive accumulation of visceral adipose tissue (VAT), and an increased risk of glucose intolerance, type II diabetes, dyslipidemia, hypertension is well understood.[4] In addition, it has been observed that there is an intergenerational cycle of obesity. For example, premature or macrosomal children from the general population whose mothers were obese were found at risk of obesity.[5,6] Genetic predisposition to excessive accumulation of visceral fat has been confirmed.[7] Fat accumulation in the body requires monitoring. It is generally believed that the assessment of fat content by dual energy X-ray absorptiometry (DXA) compared to magnetic resonance or computed tomography (CT) is cheaper, more accurate, and the exposure to the X radiation is low (radiation dose during DXA body scanning is 1%–10% of the radiation dose received by the body during lung radiography). In addition, body weight measurements made using DXA are reproducible and allow, in addition to assessing nutritional status, the differentiation of body composition.[8,9] Although the above-described methods have been identified as the gold standard for evaluating the amount and distribution of adipose tissue in the body, they are not widely available

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among others due to high costs.[10,11] In clinical practice and public health, the anthropometric method is widely used, which requires little financial and technical skill.[12] Abnormal waist circumference (WC) has become one of the criteria for the diagnosis of metabolic syndrome. Modified NCEP-ATPIII criteria[2] and the International Diabetes Federation criteria[3] are currently valid criteria for the diagnosis of metabolic syndrome.

The aim of the present study was to investigate correlations between the chosen body composition parameters assessed with DXA and the anthropometric method used to assess body fat in women over 50 years of age.

MATERIALS AND METHODS

Fifty women aged 51–85 were assessed. Women in the involutional period, after the menopause, were chosen as the group to examine. The collected information about the last menstruation and hormonal substitution were not exact enough to analyze. All women were inhabitants of the city of Rzeszów (Poland). They had been recruited during talks in Senior Clubs in Rzeszów and during the classes at the "University of the Third Age of University" of Rzeszów. At first, 51 women volunteered to participate in the examination. All of the women were able to stand and change the position into compulsory ones associated with performing the DXA examination. One of the women refused to participate in the DXA examination because of exposition to the X radiation. Fat and lean mass were evaluated with DXA. The scanner used for the examination was Lunar iDXA by GE Healthcare, based on dual-energy X-ray absorptiometry (typical scanning time and radiation dose, with the best precision: Anterior-Posterior Spine: 60 s; 42 μGy, femur: 60 s; 42 μGy, total body/body composition: 6 min; 0.4 μGy). Android/gynoid ratio (A/G ratio), body mass index (BMI) DXA (kg/m^2), visceral adipose tissue (VAT) mass (g), gynoid fat (GF) (g), android fat (AF) (g), GF (g), android region % fat (AR %F), gynoid region % fat (GR %F), right leg fat (RLF) (g), right leg region %F (RLR %F), right leg lean (RLL) (g), right arm fat (RAF) (g), right arm region %F (RAR %F), right arm lean (RAL) (g), and total region %Fat (TR %F) were read. The anthropometric assessment of nutritional status consisted of measurements of body weight, body height, upper limb length, lower limb length, waist, hip, arm, forearm, thigh, and shin circumferences and calculation of body proportion ratios. The technique of anthropometric measurements was based on anthropological methods used in international research. The measurements were taken with: medical scales (kg), anthropometer (cm), anthropometric tape (cm), and skinfold caliper (mm). The selected anthropometric features include the arm circumference (AC), forearm circumference (FC), thigh circumference (TC), shank circumference (SC), umbilical skinfold thickness (UST), and selected body proportion ratios: waist circumference to hip circumference ratio (WHR), waist circumference to height ratio (WHtR), BMI, Upper Limb Muscularity Index, FC to length of the upper limb ratio, Lower Limb Muscularity Index (LLMI), SC to length of the lower limb ratio, Škerlj (ratio of greatest thigh circumference to height) Index (ŠI), arm total cross section area (A_{TB}). Only the right limbs were evaluated, it was the dominant side in all the participants. The Spearman's rho correlation was calculated to examine the interrelations between the obtained parameters assessed with DXA and anthropometric method.

Ethics

The study was approved by Bioethics commission at the Faculty of Medicine, University of Rzeszow, Poland. The participants gave the written informed consent related to participation in the study.

Statistical analysis

For all parameters assessed by the DXA and the anthropometric method, mean average ($\bar{x}$), median (Me), and standard deviation (s) were calculated; minimal (Min) and maximal (Max) values were given. Because of the unfulfilled assumption of the normal distribution of two variables correlated with each other, the Spearman's rho correlation was calculated to examine the interrelations between the obtained parameters assessed with DXA and anthropometric method.

RESULTS

Statistical characteristic of age of examined women: $\bar{x}$ = 68, Me = 69, s = 9.123 years. The BMI values in the women examined with DXA method ($\bar{x}$ = 28.44, Me = 28.05, s = 4.931, Min = 20.10, Max = 44.20 kg/m^2) were similar to those calculated from the body proportions ratio ($\bar{x}$ = 28.40, Me = 28.76, s = 5.12, Min = 18.03, Max = 43.54 kg/m^2). In Table 1, statistical characteristics of all of the collected parameters of DXA [position: 1–14] and anthropometric parameters are presented [position: 15–32].

The Spearman's rho correlation showed a statistically significant association ($P < 0.05$) between: RAL and AC ($R = 0.328$, $P = 0.020$), RAL and FC ($R = 0.357$, $P = 0.011$), RAL and A_{TB} ($R = 0.328$, $P = 0.020$). These correlations were positive, of moderate level (R = 0.30–0.49). In line with the increase of RAL value, AC, FC, and A_{TB} increase [Table 2].

The Spearman's rho correlation showed a statistically significant association ($P < 0.05$) between: RLF and TC ($R = 0.418$, $P = 0.003$), RLF and SC ($R = 0.367$, $P = 0.009$), RLF and LLMI (R = 0.300, $P = 0.034$), RLF %F and TC ($R = 0.370$, $P = 0,008$), RLF %F and SC ($R = 0.411$, $P = 0.030$), RLF %F and

Table 1: Statistical characteristics: Age of participants and collected parameters

Statistical characteristics			$\bar{x}$	Median	SD	Minimal	Maximal
a. Age of subjects (years)			68	69	9.23	51	85
b. Collected parameters: Order, abbreviation, appellation			-	-	-	-	-
1	A/G ratio	Android/gynoid ratio	1.03	1.03	0.17	0.48	1.40
2	BMI dexa	Body mass index DEXA (kg/m^2)	28.44	28.05	4.93	20.10	44.20
3	VAT mass	Visceral adipose tissue mass (g)	1168.06	1011.50	683.79	194.00	2751.00
4	AF	Android fat (g)	2564.90	2320.00	1052.16	615.00	5441.00
5	GF	Gynoid fat (g)	4768.78	4506.5	1276.72	2043	8024
6	AR %F	Android region %fat	0.44	0.45	0.10	0.17	0.63
7	GR %F	Gynoid region %fat	0.42	0.43	0.05	0.271	0.512
8	RLF (g)	Right leg fat (g)	4720.3	4447.00	1329.93	2114.00	7669.00
9	RLR %F	Right leg region %fat	0.38	0.39	0.05	0.24	0.47
10	RLL	Right leg lean (g)	7005.18	6887.00	982.76	5400.00	8975.00
11	RAF	Right arm fat (g)	1742.74	1625	561.88	803	3939.00
12	RAR %F	Right arm region %fat	0.41	0.41	0.06	0.25	0.52
13	RAL	Right arm lean (g)	2292.92	2209.00	404.49	1673.00	3755.00
14	TR %F	Total region %fat	0.40	0.41	0.06	0.23	0.52
15	BH	Body height (cm)	159.81	159.00	5.64	150.10	179.20
16	BW	Body weight (kg)	72.62	71.30	12.97	45.30	107.50
17	LUL	Length of upper limb	70.46	70.20	2.82	64.10	77.90
18	LLL	Length of lower limb	81.84	81.50	4.25	70.20	91.10
19	AC	Arm circumference (cm)	32.11	32.30	3.82	25.10	43.10
20	FC	Forearm circumference (cm)	25.32	25.00	2.03	21.30	31.30
21	TC	Thigh circumference (cm)	57.63	57.10	5.34	47.40	68.80
22	SC	Shank circumference (cm)	38.06	38.10	3.78	28.10	46.20
23	WC	Waist circumference (cm)	94.49	94.50	11.14	73.40	119.30
24	HC	Hip circumference (cm)	108.42	108.50	10.04	80.20	135.10
25	UST	Umbilical skinfold thickness (mm)	47.73	46.00	18.85	10.00	90.00
26	WHR	Waist circumference to hip circumference ratio	0.87	0.88	0.06	0.72	0.96
27	WHtR	Waist circumference to height ratio	0.59	0.60	0.08	0.44	0.78
28	BMI	Body mass index (kg/m^2)	28.47	28.80	5.14	18.02	43.54
29	ULMI	Upper Limb Muscularity Index	45.65	44.76	5.79	34.67	60.31
30	LLMI	Lower Limb Muscularity Index	46.59	46.01	4.92	34.57	55.69
31	ŠI	Škerlj Index	36.08	35.69	3.35	28.66	42.86
32	A_{TB}	Arm total cross section area (cm^2)	83.18	81.49	20.21	49.73	147.14

SD=Standard deviation

LLMI (*R* = 0.304, *P* = 0.032), and TR %F and SC (*R* = 0.313, *P* = 0.027). These correlations were positive, of moderate level (0.30–0.49). In line with the increase of RLF and RLF %F values, TC, SC, and LLMI also increase. Moreover, SC also increases in line with TR%F [Table 2].

The Spearman's rho correlation showed a statistically moderate association (*P* < 0.05) between: VAT Mass and WHtR (*R* = 0.305, *P* = 0.031), VAT mass and BMI (*R* = 0.279, *P* = 0.05), AF and WHtR (*R* = 0.287, *P* = 0.044), GF and ŠI (*R* = 0.318, *P* = 0.025), GF and BMI (*R* = 0.289, *P* = 0.042), AR %F and WHtR (*R* = 0.333, *P* = 0.018), AR %F and BMI (*R* = 0.298, *P* = 0.035), and GR %F and WHtR (*R* = 0.309, *P* = 0.029). These correlations were positive, of moderate level (*R* = 0.30–0.49) or of weak level (*R* = 0.00–0.29). In line with the increase of VAT mass value, WHtR, and BMI also increase. What is more, in line with the increase of AF value, WHtR also increases. Moreover, ŠI and BMI increase in line with GF; WHtR and BMI increase in line with AR %F; WHtR increases in line with GR %F [Table 2].

DISCUSSION

Our research was conducted among 50 women aged 51–85 years. According to the literature, in women, the percentage of fat relative to total body mass is greater than in men, already since childhood.[13] In girls, young and mature women, there is a tend to accumulate adipose tissue at the buttock–thigh area.[13,14] After menopause, sex differences disappear, and there is a tendency to accumulate visceral fat, the tendency for metabolic, inflammatory, and cardiovascular complications is increasing. In obese postmenopausal women, the risk of breast cancer, endometrium, colorectal, gall bladder, pancreas, and kidney cancer is also increasing.[13] We observed that an accumulation of adipose tissue in the visceral, abdominal, and buttock–thigh areas in postmenopausal women co-occurred with the increase of WHtR values. For example, the parameters determined with the DXA method, such as VAT mass, GR %F, and AR %F, moderately, positively

Table 2: Fat and lean mass of upper limb, lower limb, body: Assessment with dual-energy X-ray absorptiometry and anthropometric method

a. Fat and lean mass of the upper limb - assessment with dual-energy X-ray absorptiometry and anthropometric method

Spearman's rho correlation	AC	FC	ULMI	A_{TB}
RAF				
R	0.215	0.232	0.195	0.215
P	0.134	0.104	0.174	0.134
n	50	50	50	50
RAR %F				
R	−0.034	0.019	−0.012	−0.034
P	0.817	0.898	0.933	0.817
n	50	50	50	50
RAL				
R	0.328*	0.357*	0.268	0.328*
P	0.020	0.011	0.060	0.020
n	50	50	50	50
TR %F				
R	0.138	0.127	0.086	0.138
P	0.338	0.379	0.555	0.338
n	50	50	50	50

b. Fat and lean mass of the lower limb - assessment with dual-energy X-ray absorptiometry and anthropometric method

Spearman's rho correlation	TC	SC	LLMI
RLF			
R	0.418**	0.367**	0.300*
P	0.003	0.009	0.034
n	50	50	50
RLF %F			
R	0.370**	0.411**	0.304*
P	0.008	0.003	0.032
n	50	50	50
RLL			
R	0.254	0.178	0.138
P	0.075	0.215	0.339
n	50	50	50
TR %F			
R	0.246	0.313*	0.227
P	0.085	0.027	0.113
n	50	50	50

c. Fat and lean body mass - assessment with dual-energy X-ray absorptiometry and anthropometric method

Spearman's rho correlation	ŠI	WHR	WHtR	UST	BMI
A/G ratio					
R	0.040	0.205	0.235	0.058	0.221
P	0.784	0.154	0.101	0.688	0.124
n	50	50	50	50	50
BMI dexa					
R	0.209	0.062	0.245	0.097	0.261
P	0.145	0.668	0.086	0.502	0.067
n	50	50	50	50	50
VAT mass					
R	0.137	0.232	0.305*	0.047	0.279*
P	0.343	0.105	0.031	0.748	0.050
n	50	50	50	50	50
AF					
R	0.163	0.157	0.287*	0.144	0.271
P	0.257	0.277	0.044	0.319	0.057
n	50	50	50	50	50

Contd...

Table 2: Contd....

Spearman's rho correlation	ŠI	WHR	WHtR	UST	BMI
GF					
R	0.318*	0.035	0.272	0.185	0.289*
P	0.025	0.812	0.056	0.199	0.042
n	50	50	50	50	50
AR %F					
R	0.160	0.179	0.333*	0.137	0.298*
P	0.267	0.213	0.018	0.342	0.035
n	50	50	50	50	50
GR %F					
R	0.263	0.053	0.309*	0.136	0.278
P	0.065	0.713	0.029	0.346	0.051
n	50	50	50	50	50

**Correlation is significant at the level of 0.01 (bilaterally); *Correlation is significant at the level of 0.05 (bilaterally). A/G ratio=Android/gynoid ratio; BMI=Body mass index; VAT=Visceral adipose tissue; AR %F=Android %fat; GF=Gynoid fat; GR %F=Gynoid region % fat; AF=Android fat; ŠI=Škerlj Index; WHR=Waist circumference to hip circumference ratio; WHtR=Waist circumference to height ratio; UST=Umbilical skinfold thickness; RAF=Right arm fat; RAR %F=Right arm region %fat; RAL=Right arm lean; TR %F=Total region %fat; AC=Arm circumference; FC=Forearm circumference; ULMI=Upper Limb Muscularity Index; A_{TB}=Arm Total Cross Section Area; RLF %F=Right leg fat %fat; RLL=Right leg lean; TC=Thigh circumference; SC=Shank circumference; LLMI=Lower Limb Muscularity Index

correlated with WHtR index, and the correlation coefficient was statistically significant.

The complications resulting from the accumulation of visceral fat are due to its function. As it appears from the name itself in abdominal obesity, adipose tissue accumulates in the subcutaneous layer of the anterior abdomen or visceral abdominal wall. Moreover, the essence of pathology does not refer only to the location. Subcutaneous adipose tissue differs from visceral one with gene expression and endocrine profile.[15] VAT is actively involved in systemic metabolic changes. In response to specific stimulation of the receptors, it secretes adipokines. Therefore, the concentration of adipokines in the blood reflects its metabolic activity.[16] For example, adiponectin enhances insulin sensitivity, resistin increases insulin resistance, and leptin has anorexigenic activity.[17] Grelin is an antagonist hormone for leptin, with orexigenic activity, it is secreted by the gastric mucosa.[18] Adiponectin, resistin, lectin not only participate in metabolic but also immunological processes.[19] It was shown that physical activity has an effect on the concentration of selected adipokines. Forty middle-aged, sedentary women underwent 16 weeks of training. One subgroup participated in aerobics, the other subgroup in core exercise. Training was conducted for 1 h 4 days a week. Dosage of exercise intensity was based on the Karvonen rule. It was found that after 16 weeks of training. There was a statistically significant increase in serum adiponectin and resistin levels, whereas the level of leptin and ghrelin did not change. In addition, BMI was reduced.[18] These studies indicate that enrichment of the methodology has demonstrated not only weight loss after treatment but also favorable metabolic profile changes. In prospective, similar studies, it would be interesting to enrich methodology and assess correlations between biochemical and anthropometric indices and DXA.

The relationship between the accumulation of VAT and the resulting complications was established on the basis of studies conducted using various methods. To prove that the excessive VAT promotes the development of metabolic syndrome, type 2 diabetes, hypertension, and coronary heart disease, fatty liver-were used together CT, DXA, and anthropometric method (BMI, WC). The study was conducted among women over the age of 40 with BMI of at least 35, of which 1066 were pairs of monozygotic twins, 2204 pairs of dizygotic twins, and 187 from single pregnancies. It was found that VAT accumulation was associated with familial predisposition, with an increased risk of type II diabetes, hypertension, and elevated levels of alanine transaminase.[7] However, methods were not compared among themselves. Furthermore, in other population-based studies using only anthropometric methods, it was confirmed that obesity was one of the main risk factors for type 2 diabetes. Eleven-year follow-up was performed among 12,121 participants aged 45–46 years with 1359 cases of type 2 diabetes being diagnosed. It has been established that BMI, WHR, and WHtR values help to determine the risk of developing diabetes among both sexes.[1] Studies of 15,242 Caucasian and Afroamerican adults have shown that anthropometric parameters: BMI, WC, WHR, and WHtR were predictive of the risk for type II diabetes in both races.[4] Based on a study of 155 middle-aged women mean, it was found that WHtR has been shown to correlate best with the risk of developing cardiovascular disease (score-systems: Framingham and Prospective Cardiovascular Munster Study) and the risk of developing type II diabetes mellitus (QDScore system.[20] Predictive value of anthropometric indicators was compared. Studies of 2339 children and adolescents aged 8–18 years using DXA and anthropometric methods have shown that the WHtR identifies VAT accumulation better than BMI and WC together.[21] In our own research, it was determined that in the assessment of abdominal obesity in women aged 51–80 the following parameters determined by DXA and anthropometric methods were correlated: AF with WHtR, as well as VAT mass with WHtR and BMI; AR %F with WHtR and BMI. It confirms that the researchers appropriately select the parameters to assess abdominal obesity. WHtR was used to diagnose abdominal obesity. It was recognized that the diagnosis of abdominal obesity in children and adolescents could be based on WHtR values ≥0.5.[14] The measurement of the thickness of the skin-fat folds with the use of a skinfold caliper also reveals body composition. For example, in anthologometric studies evaluating the development of skin-fat folds according to anthropometric method measurements, different parts of the body are measured.[22] People who suffer from central obesity accumulate both VAT and subcutaneous abdominal adipose tissue. In addition, the deep layers of subcutaneous adipose tissue, which are involved in metabolic and immune responses, resemble VAT.[23] Hence, UST was measured in our studies. Other researchers have shown that among the parameters calculated with DXA, the value of VAT mass correlates with increased risk of glucose intolerance and metabolic syndrome. The study was conducted among 229 obese women aged 21–69 years.[23]

Comparative studies of the different methods used to assess VAT accumulation can be found in the literature. As it is known, 30%–35% of body fat participates in its formation. VAT consists of adipose tissue in the abdominal area, retroperitoneal space, internal genital tract, mammary gland, and skeletal muscles.[13] Perirenal adipose tissue may be a component of visceral fat and affect renal function through paracrine effects, predispose to the development of hypertension. Correlations between selected parameters evaluated using CT and anthropometric method were studied. In women, volume of perirenal adipose tissue tested with CT was not correlated with anthropometric parameters (WC, BMI), while in men, it was positively correlated with WC, but not with BMI, the adipose tissue in renal sinuses in CT was not correlated with anthropometric parameters for both sexes.[24] Lack of correlation between volume of perirenal adipose tissue tested with CT and WC, or BMI in women was unexpected. In own research, the correlation between GR% F and WHtR was surprising.

In our study, we focused on the correlation between traditional anthropometric parameters and the DXA method used for the identification of abdominal and gluteal-femoral obesity. There was a moderate correlation between AF and WHtR, VAT mass, and WHtR and BMI, AR %F WHtR and BMI. Based on the literature examples outlined above, it is clear that these parameters correlate with cardiovascular and metabolic complications associated with VAT accumulation. Interestingly, no correlation was found between the DXA and the UST anthropometric parameter. There was also a positive correlation of moderate strength between parameters from both groups describing gluteal-femoral obesity: GF and ŠI and BMI.

It has now been emphasized that a methodological consequence and simplicity of implementation are important in the long-term monitoring of body fat assessment in patients undergoing therapy. A study of 69 young, not obese, healthy individuals found that tetrapolar or bipolar bioelectrical impedance analysis and near-infrared interactivity (NIR) analyzers should not be used interchangeably due to differences between the results obtained on the basis of different devices. Analyzers of this type can be used at home or in fitness clubs such as weight control.[10] Anthropometric measurements are also easy to make and can be carried out at home. An example is the use of an unstretchable belt for WC measurement.

About 65%–70% of adipose tissue builds the subcutaneous layer in the gluteal-femoral region and the anterior wall of the abdomen. The excess of subcutaneous fat in these areas of the body is of esthetic significance for women. Actions to reduce its accumulation also need to be monitored. Ultrasound therapy with low frequency and intensity plays an important role in esthetic medicine. Ultrasound and DXA were used to monitor the effects of therapy. Twenty-eight women with normal body weight and mean age 25.5 years were subjected to 10 weeks of therapy by the buttocks and hips sonication (150 kHz, 1.65W0/cm^2) for 48 min twice a week. A statistically significant decrease in the thickness of the dermal fatty fold in the buttock area as well as the fat mass of the lower limb and torso was obtained.[25] Microdialysis can be used to evaluate the metabolic activity of adipose tissue in a specific region of the body.[26] Femoral adipose tissue is considered metabolically inactive, but the hypertrophy of its cells can lead to cellulite. Its lipolytic activity was measured before and after the application of mechanical massage. Lipolytic activity was measured using microdialysis technique, evaluating the concentration of glycerol after lipolytic infusion. The study was performed in 9 women with cellulite lesions undergoing 12 sessions of mechanical massage. Increased lipolytic activity in adipose tissue has been demonstrated after the intervention, in addition, a reduction in the circumference of the thigh was observed. The reduction of the thigh circumference coincided with the increased lipolysis of subcutaneous adipose tissue in this region of the body.[27]

Rathnayake *et al*. performed research among 165 women aged 30–60 years from Galle District, Sri Lanka. They calculated correlation coefficients between Appendicular Skeletal Muscle Mass measured by dual-energy x-ray absorptiometry and upper AC (0.73), thigh circumference (0.56), calf circumference (0.52). All variables were significantly correlated at <0.001 level (Pearson's test).[28]

Diano *et al*. did not confirm that anthropometric measures of AC and thigh circumference (TC) are representative for nonbone lean mass (LM) of upper and lower limbs, respectively.[29]

Kagawa *et al*. assessed body composition in the group of 139 Japanese females aged 18–27 (BMI range: 15.1–29.1 kg/m^2) using whole-body DXA and anthropometry. The authors analyzed correlations between percentage of body fat (%BF) estimated with DXA and selected anthropometric parameters. Triceps Skinfold reached the highest correlation with %BF, followed by Supraspinale and Biceps Skinfolds, suggesting that Japanese women may have higher subcutaneous fat deposition in the upper limb and the torso. The researcher drew attention to interracial differences.[30]

In our studies, there was a moderate correlation between both types of parameters describing the lower limb: RLF and TC, SC, LLMI, and RLF F% and TC, SC, LLMI, and TR F% and SC. These parameters characterize the accumulation of adipose tissue in the lower limb, although the name of the LLMI suggests a link with the lower limb musculature. In this case, the value of the anthropometric indicator is limited. In addition, a moderate correlation was obtained between both types of parameters describing the upper limb: RAL and AC, FC, A_{TB} (these parameters describe the upper limb musculature).

Other studies using the DXA and anthropometric methods demonstrated usefulness of anthropometric index of the mid-arm muscle circumference (MAMC) in the assessment of muscle mass in the elderly.[31] It was also found that lower MAMC is associated with a higher mortality risk in males.[32]

Being aware of the impact of adipose tissue not only on appearance but also above all on human health, it requires us to choose the most effective and simplest and widely available methods of evaluation. Due to invasiveness (X-rays) and difficult access to the DXA test, anthropometric measurements seem to be a good alternative in the monitoring of the body fat content.

CONCLUSION

The selected parameters assessed with DXA were significantly correlated with the selected parameters assessed with anthropometric methods. WHtR anthropometric parameter is significantly correlated with DXA parameters: VAT Mass, GR %F, AR %F.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Hardy DS, Stallings DT, Garvin JT, Xu H, Racette SB. Best anthropometric discriminators of incident type 2 diabetes among white and black adults: A longitudinal ARIC study. PLoS One 2017;12:e0168282.
2. Bi X, Seabolt L, Shibao C, Buchowski M, Kang H, Keil CD, *et al.* DXA-measured visceral adipose tissue predicts impaired glucose tolerance and metabolic syndrome in obese Caucasian and African-American women. Eur J Clin Nutr 2015;69:329-36.
3. Komperda J, Żurkowska J, Czapka M, Szczepańska M, Pierzak-Sominka J. Zespół metaboliczny – Przegląd piśmiennictwa (Metabolic syndrome – Review of the literature). Probl Nauk Stosowanych 2014;2:149-56.
4. Hardy DS, Stallings DT, Garvin JT, Gachupin FC, Xu H, Racette SB. Anthropometric discriminators of type 2 diabetes among white and black American adults. J Diabetes 2017;9:296-307.
5. Li P, Yang F, Xiong F, Huo T, Tong Y, Yang S, *et al.* Nutritional status and risk factors of overweight and obesity for children aged 9-15 years in Chengdu, Southwest China. BMC Public Health 2012;12:636.
6. Ghanbari S, Ayatollahi SM. Comparing the role of standard references on the prevalence of Iranian children and adolescents' overweight and obesity: A systematic review and meta-analysis. J Res Med Sci 2016;21:121.
7. Direk K, Cecelja M, Astle W, Chowienczyk P, Spector TD, Falchi M, *et al.* The relationship between DXA-based and anthropometric measures of visceral fat and morbidity in women. BMC Cardiovasc Disord 2013;13:25.
8. Micklesfield LK, Goedecke JH, Punyanitya M, Wilson KE, Kelly TL. Dual-energy X-ray performs as well as clinical computed tomography for the measurement of visceral fat. Obesity (Silver Spring) 2012;20:1109-14.
9. Williams JE, Wells JC, Wilson CM, Haroun D, Lucas A, Fewtrell MS, *et al.* Evaluation of lunar prodigy dual-energy X-ray absorptiometry for assessing body composition in healthy persons and patients by comparison with the criterion 4-component model. Am J Clin Nutr 2006;83:1047-54.
10. Bigornia SJ, LaValley MP, Benfield LL, Ness AR, Newby PK. Relationships between direct and indirect measures of central and total adiposity in children: What are we measuring? Obesity (Silver Spring) 2013;21:2055-62.
11. Samouda H, de Beaufort C, Stranges S, Guinhouya BC, Gilson G, Hirsch M, *et al.* Adding anthropometric measures of regional adiposity to BMI improves prediction of cardiometabolic, inflammatory and adipokines profiles in youths: A cross-sectional study. BMC Pediatr 2015;15:168.
12. Janssen I, Katzmarzyk PT, Ross R. Waist circumference and not body mass index explains obesity-related health risk. Am J Clin Nutr 2004;79:379-84.
13. Siemińska L. Adipose tissue. Pathophysiology, distribution, sex differences and the role in inflammation and cancerogenesis. Endokrynol Pol 2007;58:330-42.
14. Felińczak A, Szymańska-Pomorska G, Seń M, Misiak K, Hamma F. Ocena częstości występowania zespołu metabolicznego u młodzieży gimnazjalnej (Evaluation of the Prevalence of Metabolic Syndrome Components in Junior High School Pupils). In: Seń M, Dębska G, edirors. Zagrożenia

zdrowotne wśród dzieci i młodzieży (Health risks among children and adolescents). Kraków: Krakowskie Wydawnictwo Edukacyjne; 2011. p. 11-22.
15. Palou M, Priego T, Sánchez J, Rodríguez AM, Palou A, Picó C, *et al.* Gene expression patterns in visceral and subcutaneous adipose depots in rats are linked to their morphologic features. Cell Physiol Biochem 2009;24:547-56.
16. Yeung EH, McLain AC, Anderson N, Lawrence D, Boghossian NS, Druschel C, *et al.* Newborn adipokines and birth outcomes. Paediatr Perinat Epidemiol 2015;29:317-25.
17. Skowrońska B, Fichna M, Fichna P. The role of adipose tissue in the endocrine system. Endokrynol Otyłość Zaburzenia Przemiany Materii 2005;1:21-9.
18. Potempa M, Jonczyk P, Janerka M, Kucharzewski M. Ghrelin – hormone which regulates the energy metabolism of the body, clinical significance. Part 2. Influence on arbohydrate and lipid metabolism. Med Metab 2014;18:74-82.
19. Ozcan O, Bostanci MÖ, Cicek G, Yamaner F. The effects of two different exercise programmes on adipose tissue hormones in sedentary middle-aged women. Arch Physiol Biochem 2015;121:50-5.
20. Rastović M, Srdić Galić B, Stokić E, Sakac D, Mikalacki M, Korovljev D. Anthropometric indicators of mass and distribution of adipose tissue in the assessment of cardiovascular and diabetes risk in women. Med Pregl 2013;66:11-8.
21. Brambilla P, Bedogni G, Heo M, Pietrobelli A. Waist circumference-to-height ratio predicts adiposity better than body mass index in children and adolescents. Int J Obes (Lond) 2013;37:943-6.
22. Golec J, Czechowska D, Masłoń A, Tomaszewski K, Mikulska Golec E. Ocena uwarunkowań występowania nadwagi otyłości w wybranych grupach młodzieży. (Evaluation of factors determining of prevalence of obesity in selected groups of adolescents). Ostry Dyżur 2013;4:132-7.
23. Cnop M, Landchild MJ, Vidal J, Havel PJ, Knowles NG, Carr DR, *et al.* The concurrent accumulation of intra-abdominal and subcutaneous fat explains the association between insulin resistance and plasma leptin concentrations: Distinct metabolic effects of two fat compartments. Diabetes 2002;51:1005-15.
24. Favre G, Grangeon-Chapon C, Raffaelli C, François-Chalmin F, Iannelli A, Esnault V. Perirenal fat thickness measured with computed tomography is a reliable estimate of perirenal fat mass. PLoS One 2017;12:e0175561.
25. Milanese C, Cavedon V, Piscitelli F, Zancanaro C. Effect of low-intensity, low-frequency ultrasound treatment on anthropometry, subcutaneous adipose tissue, and body composition of young normal weight females. J Cosmet Dermatol 2014;13:202-7.
26. Maruniak-Chudek I, Swietliński J. Microdialysis: Its application in experimental and clinical studies of disturbances in tissue metabolism. Postepy Hig Med Dosw (Online) 2007;61:384-402.
27. Monteux C, Lafontan M. Use of the microdialysis technique to assess lipolytic responsiveness of femoral adipose tissue after 12 sessions of mechanical massage technique. J Eur Acad Dermatol Venereol 2008;22:1465-70.
28. Rathnayake N, Alwis G, Lenora J, Lekamwasam S. Concordance between appendicular skeletal muscle mass measured with DXA and estimated with mathematical models in middle-aged women. J Physiol Anthropol 2018;37:19.
29. Diano D, Ponti F, Guerri S, Mercatelli D, Amadori M, Aparisi Gómez MP, *et al.* Upper and lower limbs composition: A comparison between anthropometry and dual-energy X-ray absorptiometry in healthy people. Arch Osteoporos 2017;12:78.
30. Kagawa M, Kuroiwa C, Uenishi K, Mori M, Hills AP, Binns CW, *et al.* New percentage body fat prediction equations for Japanese females. J Physiol Anthropol 2007;26:23-9.
31. Carnevale V, Castriotta V, Piscitelli PA, Nieddu L, Mattera M, Guglielmi G, *et al.* Assessment of skeletal muscle mass in older people: Comparison between 2 anthropometry-based methods and dual-energy X-ray absorptiometry. J Am Med Dir Assoc 2018;19:793-6.
32. Wu LW, Lin YY, Kao TW, Lin CM, Liaw FY, Wang CC, *et al.* Mid-arm muscle circumference as a significant predictor of all-cause mortality in male individuals. PLoS One 2017;12:e0171707.