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Body fat distribution, blood pressure and blood glucose in Egyptian obese women undergoing a weight control program

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Körperfettverteilung, Blutdruck und Blutzuckerspiegel bei ägyptischen übergewichtigen Frauen unter einem Gewichtskontrollprogramm

Summary: In a sample of 92 obese healthy women, 35 of them were chosen to follow a weight control program comprising both caloric restriction and exercise for three months. They were matched for age and weight with the remaining 57 women who also served as a control group. The entire sample was further stratified according to age into two categories of 20–34 and 35–50 years. The caloric supply was restricted to about 1000 kcal/day, in addition to a 1-h session of mild exercise which was performed twice weekly; the subjects' energy expenditure was 2200 kcal/day. Only the mean values of the biceps, triceps, and suprailiac skinfold measurements were significantly decreased ($p < 0.05$) in the younger trained dieters when compared to their counterpart sedentary controls. On the other hand, obvious group variations appeared between body fat distribution when related to body weight and to blood pressure. Blood glucose revealed normal levels in the whole sample. Mean values were numerically lower in the older trained dieters than their matched sedentary controls, while they were significantly lower ($p < 0.05$) in the younger trained dieters. Although blood pressure was in the normal range for all participants, a non-significant decrease was recorded for both age groups of the obese trained dieters upon completion of the program. The systolic blood pressure decreased by 5.4 % and the diastolic by 6.7 % regarding the younger age, while the decrease in the older age was 3.5 % for the systolic and 4.8 % for the diastolic blood pressure. It was concluded that, although the trained dieters were still obese, the caloric restriction was promoted synergistically by exercise, leading to a more harmonious fat distribution and to lower normal levels of blood pressure and blood glucose.

Zusammenfassung: Von 92 übergewichtigen gesunden Frauen wurden 25 einem dreimonatigen Gewichtskontrollprogramm unterworfen, das aus Energierestriktion und leichtem Sport bestand. Diese 35 Versuchspersonen (VP) entsprachen den restlichen als Kontrollgruppe dienenden 57 hinsichtlich Alter und Körpergewicht. Die Versuchsgruppe wurde in 2 Kategorien unterteilt, und zwar 20–34 bzw. 35–50jährige. Die Energieaufnahme wurde auf 1000 kcal täglich limitiert, dazu wurde zweimal wöchentlich leichter Sport getrieben. Der geschätzte Energieverbrauch lag bei 2200 kcal täglich. Das dreimonatige Programm führte zu einer Gewichtsreduktion aller VP, jedoch in unterschiedlichem Ausmaß. Die Werte der Bizeps-, Trizeps- und Suprailiakel-Hautfalten nahmen signifikant ab ($p < 0,05$), jedoch ausgeprägt nur bei den jüngeren VP. Das Körpergewicht korrelierte signifikant ($p < 0,05$) mit vielen anthropometrischen Messungen zur Körperfettverteilung, unterschiedlich bei den verschiedenen Versuchsgruppen. Nach Ende des Programms nahm der durchschnittliche Blutzuckerspiegel der jüngeren VP signifikant ($p < 0,05$) ab. Bei den älteren VP bestand die gleiche Tendenz, jedoch nicht signifikant. Der Blutdruck aller VP wies am Anfang der Studie Werte im Normalbereich auf. Nach dem Programm erniedrigte sich systolischer und diastolischer Blutdruck bei den jüngeren VP um 5,4 bzw. 6,7 %, bei den älteren VP betrugen die entsprechenden Werte 3,5 bzw. 4,8 %.

Es wird geschlossen, daß – obwohl die VP weiterhin übergewichtig waren – Energiereduktion und Sport synergistisch zu einer harmonischeren Körperfettverteilung und niedrigeren Normwerten des Blutdruckes und der Blutzuckerspiegel führten.

Key words: Anthropometry – blood pressure – blood glucose – obesity – diet

Schlüsselwörter: Anthropometrie – Blutdruck – Blutzucker – Übergewicht – Diät

Introduction

The association between hypertension and obesity have been documented by many workers (1–4). Body weight loss leads to decrease in both systolic (SBP) and diastolic (DBP) blood pressure in obese individuals (5). However, body fat distribution and localization of adipose tissue are more closely related to metabolic and cardiovascular risk factors than obesity itself (6–9). Further, in prospective studies of healthy individuals, body fat distribution, as assessed by the waist to hip girth ratio, is a strong predictor of insulin resistance, hyperinsulinemia, and glucose intolerance (10). Numerous studies have shown that these metabolic disturbances were more closely associated with the level of abdominal fat than excess adiposity per se (11–14). Thus, recent recommendations for weight reduction encourage the combination of energy intake restriction and exercise (15). Incorporation of regular aerobic exercise into a diet program should produce changes in physical fitness and body composition, and evidence supports the concept that morphological changes are more pronounced when a large amount of exercise is performed (16).

In this study, our observations on the effect of exercise training and energy intake restriction on the regional variation of body fat will be discussed. In addition, the relation between this effect and blood pressure and blood glucose as easily measured parameters – which are, at the same time, risk factors – will be also analyzed.

Subjects and Methods

A sample of 92 obese healthy women aged 20–50 years was taken at random from the out-patient obesity centre, Sahel Hospital, Cairo. Thirty-five women were chosen to follow a weight-control program comprising both caloric restriction and exercise for 3 months. They were matched for age and weight with the remaining 57 women who also served as a control group. The entire sample was further stratified according to age into two categories of 20–34 and 35–50 years. The weight control program consisted of:

1. Physical training at the rate of two sessions per week of mild exercise, each session lasting for 60 min.
2. Diet regimen: women were instructed to consume a well-balanced diet providing about 1000 kcal/day.
3. Mean energy expenditure for the obese sedentary control women was 2100 ± 108.36 kcal/day, and that for the trained dieters was 2200 ± 145.09 kcal/day. All participants
   were housewives performing mild household activities, with the addition of the extra 2 h of mild exercise per week for the trained dieters, resulting in a negative energy balance of about 1400 kcal/day.

Anthropometric data were collected with subjects dressed in light clothing. Height and weight were taken following the standards methods (17). Harpenden caliper was used to measure skinfold thicknesses at the following sites (triceps, biceps, subscapular, suprailiac, abdominal and thigh). Girths were measured using a flexible light, metal tape at three sites (Abdominal I "minimal waist", maximum hip girth, and shoulder).

Blood pressure was obtained with participants sitting quietly for 5 min. using a mercury sphygmomanometer. Three readings were made, the means of the second and third readings of the first (systolic) and fifth (diastolic) Korotkoff sounds were used. The following indices of obesity were calculated from anthropometric data: body mass index (BMI) weight in kg divided by height in square meters, sum of four skinfolds (triceps, biceps, subscapular and suprailiac) to estimate percent of body fat (18), lean body mass (LBM) was calculated as the difference between body weight and percent of body fat. Waist hip ratio (WHR) was calculated by dividing minimal waist girth by maximum hip girth. Twenty-four hour recall method was used to identify the daily intake of different foods which was further analyzed for their nutrient content (Table 1) using a food composition table (19).

Blood samples were taken in the morning after an overnight fast. Fasting blood glucose was determined in fresh samples by the method of Asatoor and King (20).

The results were expressed as the mean ± SEM, and statistical analysis was performed using Student's *t*-test and the linear regression equation to define the relation of blood pressure and blood glucose with anthropometric values.

Results

Table 2 shows the mean ± SEM of age and other anthropometric measurements together with the blood glucose values. The initial mean weight of the young (group 3) and the older (group 4) trained dieters was 100.16 ± 4.91 kg and 111.85 ± 4.44 kg, respectively; their final mean weight was 86.58 ± 4.17 kg and 98.93 ± 3.57 kg with a mean body weight loss of 13.58 ± 2.46 kg and 12.92 ± 2.01 kg, respectively. The weights of the obese sedentary controls were selected to match the final weights of trained dieters at the end of the weight control program, so that the mean weight of the young (group 1) sedentary obese controls was 94.02 ± 3.11 kg and that of the older (group 2) sedentary obese controls was 92.39 ± 2.83 kg. Group (5) represents the total numbers of both age groups of the sedentary obese controls. Group (6) represents the total values of both groups (3 and 4).

Table 3 shows the mean ± SEM of the initial and final blood pressure measurements of the obese trained dieters together with the measurements of the obese sedentary controls.

Table 4 shows the correlation coefficient between the weight and various anthropometric parameters.

Table 5 shows the correlation coefficient between each of the final systolic and final diastolic blood pressure and the various anthropometric parameters.

Table 6 shows that there was no correlation between blood glucose and any of the anthropometric parameters.

Discussion

Although the effect of exercise-training on body fat has been extensively studied, little is known about the effect of exercise training on adipose tissue distribution (21). Our results showed that the mean values of anthropometric measurements of obese control women and obese women under the weight control program were more or less similar, however, intragroup variations were quite different. By comparing the values of correlation between body weight and regional adiposity, we noted that the control obese

Table 1. Nutrients intake per subject per day

	Obese sedentary control			Obese trained dieters		
Nutrients No.	1 33	2 23	5 (Total) 56	3 17	4 16	6 (Total) 38
Animal protein (g)	39.5 ± 3.97	35.4 ± 3.61	37.8 ± 2.76	26.8 ± 2.18	28.8 ± 4.07	27.8 ± 2.24
Plant protein (g)	50.6 ± 4.95	53.5 ± 5.67	51.8 ± 3.70	13.2 ± 2.85	15.8 ± 2.62	14.5 ± 1.62
Fat (g)	88.0 ± 3.93	81.1 ± 8.37	85.2 ± 5.67	32.9 ± 3.28	35.6 ± 3.44	34.2 ± 1.62
Energy (kcal)	2286 ± 169.13	2217 ± 163.66	2258 ± 119.29	749 ± 67.72	871 ± 79.06	827 ± 49.37
Calcium (mg)	567 ± 63.81	549 ± 52.82	559 ± 43.08	372 ± 54.39	354 ± 30.41	363 ± 31.22
Iron (mg) (animal origin)	5.10 ± 0.58	6.30 ± 1.53	5.60 ± 0.71	2.6 ± 0.27	3.10 ± 0.45	2.80 ± 0.26
Iron (mg) (plant origin)	22.1 ± 2.50	25.4 ± 2.50	23.4 ± 1.80	8.60 ± 2.03	8.50 ± 1.30	8.50 ± 1.20
Retinol (μg)	1209 ± 311.14	683 ± 72.8	993 ± 187.85	510 ± 77.06	665 ± 87.34	585 ± 58.75
Thiamine (mg)	1.60 ± 0.22	1.80 ± 0.19	1.70 ± 0.15	0.80 ± 0.12	0.80 ± 0.08	0.80 ± 0.07
Riboflavin (mg)	3.10 ± 0.36	3.70 ± 0.46	3.40 ± 0.29	1.00 ± 0.12	1.20 ± 0.12	1.10 ± 0.09
Niacin (mg)	21.6 ± 1.75	22.8 ± 2.16	22.1 ± 1.35	11.37 ± 2.45	11.0 ± 1.28	11.2 ± 1.39
Ascorbic acid (mg)	114.9 ± 26.64	148.2 ± 20.62	128.6 ± 17.84	122.5 ± 17.94	146.5 ± 21.83	134.1 ± 13.99
Fiber (g)	6.50 ± 0.95	7.03 ± 0.61	7.00 ± 0.61	4.90 ± 0.57	5.80 ± 0.70	5.30 ± 0.45

mean ± SEM

Table 2. Subjects characteristics

	Obese sedentary control			Obese trained dieters		
Parameters No.	1 34	2 23	5 (Total) 57	3 18	4 17	6 (Total) 35
Age (yr)	26.03 ± 0.81	43.65 ± 1.47	33.14 ± 1.38	26.58 ± 1.02	42.53 ± 1.23	34.33 ± 1.58
Height (cm)	161.50 ± 0.41	161.12 ± 0.57	161.35 ± 0.33	160.78 ± 0.64	159.94 ± 0.93	160.37 ± 0.56
Initial weight (kg)	–	–	–	100.16 ± 4.91	111.85 ± 4.44	105.84 ± 3.42
Initial BMI	–	–	–	38.69 ± 1.91	43.56 ± 1.38	41.05 ± 1.24
Weight (kg)	94.02 ± 3.11	92.39 ± 2.83	93.36 ± 2.16	86.58 ± 4.17	98.93 ± 3.57	92.57 ± 2.92
BMI	36.02 ± 1.34	35.60 ± 1.08	35.85 ± 0.80	33.48 ± 1.62	38.56 ± 1.11	35.95 ± 1.07
Triceps sk. (mm)	36.12 ± 1.25	36.54 ± 1.31	36.28 ± 0.91	31.48 ± 1.84*	35.81 ± 1.24	33.58 ± 1.17
Biceps sk. (mm)	20.82 ± 1.30	22.91 ± 1.76	21.67 ± 1.05	16.31 ± 1.56*	22.15 ± 1.95	19.15 ± 1.32
Subscapular sk. (mm)	36.88 ± 1.57	36.98 ± 1.51	36.92 ± 1.11	34.12 ± 2.39	38.53 ± 1.95	36.26 ± 1.58
Suprailiac sk. (mm)	38.77 ± 1.44	38.13 ± 1.73	38.52 ± 1.10	32.64 ± 2.65*	36.04 ± 2.61	34.29 ± 1.86*
Abdominal sk. (mm)	37.01 ± 1.34	39.43 ± 1.41	37.96 ± 0.99	36.48 ± 2.05	38.88 ± 1.88	37.65 ± 1.39
Thigh sk. (mm)	45.67 ± 0.63	45.24 ± 1.12	45.50 ± 0.58	41.50 ± 2.02	46.33 ± 0.40	43.85 ± 1.12
Shoulder cir. (cm)	106.24 ± 1.19	106.84 ± 1.63	106.48 ± 0.96	104.71 ± 1.96	108.07 ± 1.64	106.34 ± 1.30
Abdominal I cir. (cm)	97.60 ± 2.43	100.35 ± 2.40	98.71 ± 1.74	96.34 ± 3.58	106.82 ± 2.30	101.43 ± 2.31
Hip cir. (cm)	122.29 ± 2.32	125.91 ± 1.99	123.75 ± 1.60	121.36 ± 3.49	127.56 ± 2.83	124.37 ± 2.39
LBM	52.43 ± 0.88	51.84 ± 0.82	52.19 ± 0.62	50.46 ± 1.27	52.93 ± 1.27	51.66 ± 0.91
WHR	0.80 ± 0.01	0.797 ± 0.01	0.799 ± 0.01	0.798 ± 0.02	0.839 ± 0.02	0.818 ± 0.01
Blood glucose	80.50 ± 2.42	94.89 ± 6.84	86.33 ± 3.34	71.75 ± 2.92*	82.32 ± 6.15	76.73 ± 3.36

mean ± SEM; * $p < 0.05$

Table 3. Mean ± SEM of systolic and diastolic measurements of all participants

	Obese sedentary control			Obese trained dieters		
Parameters No.	1 34	2 23	5 (Total) 57	3 18	4 17	6 (Total) 35
Initial systolic BP	–	–	–	131.42 ± 2.81	139.61 ± 3.81	135.36 ± 2.35
Initial diastolic BP	–	–	–	92.51 ± 2.38	95.37 ± 3.06	93.87 ± 2.01
Final systolic BP	130.61 ± 2.59	134.39 ± 3.17	132.14 ± 2.00	124.33 ± 3.14	134.71 ± 4.15	129.37 ± 2.69
Final diastolic BP	88.79 ± 2.00	90.22 ± 1.59	89.37 ± 1.35	86.39 ± 2.88	90.82 ± 2.33	88.54 ± 1.88
% Decrease systolic BP	–	–	–	–7.09 (5.40%)	–4.90 (3.51%)	5.99 (4.43%)
% Decrease diastolic BP	–	–	–	–6.12 (6.71%)	–4.55 (4.77%)	5.33 (5.68%)

Table 4. Correlation coefficient between body weight and anthropometric parameters

	Obese sedentary control			Obese trained dieters		
No.	1 34	2 23	5 (Total) 57	3 18	4 17	6 (Total) 35
Height	0.34	0.21	0.29*	0.09	0.43	0.27
BMI	0.99***	0.97***	0.98***	0.99***	0.96***	0.98***
Triceps sk.	0.45**	0.52**	0.47***	0.88***	0.61***	0.81***
Biceps sk.	0.33	0.51**	0.38***	0.70***	0.54**	0.66***
Subscapular sk.	0.40*	0.40	0.40***	0.70***	0.38	0.61***
Suprailiac sk.	0.33	0.22	0.30**	0.62**	0.38	0.53***
Abdominal sk.	0.27	0.18	0.23	0.51*	0.32	0.45***
Thigh sk.	0.45**	0.39	0.40***	0.40	0.35	0.37*
Shoulder cir.	0.75***	0.61***	0.68***	0.72***	0.67***	0.72***
Abdominal cir.	0.85***	0.78***	0.82***	0.82***	0.60***	0.78***
Hip cir.	0.91***	0.88***	0.87***	0.97***	0.75***	0.88***
LBM	0.98***	0.95***	0.97***	0.95***	0.97***	0.95***
WHR	0.30	0.28	0.29*	0.23	–0.14	0.16

* $p < 0.05$; ** $p < 0.02$; *** $p < 0.01$

Table 5. Correlation coefficient between the final systolic and diastolic blood pressure and anthropometric measurements

Anthropometric parameters	S.B.P						D.B.P					
	Obese sedentary control			Obese trained dieters			Obese sedentary control			Obese trained dieters		
	1	2	5 (Total)	3	4	6 (Total)	1	2	5 (Total)	3	4	6 (Total)
No.	34	23	57	18	17	35	34	23	57	18	17	35
Height	0.26	0.06	0.16	0.11	0.33	0.19	0.28	0.18	0.23	–0.06	0.41	0.17
Weight	0.69***	0.46*	0.60***	0.41	0.15	0.36*	0.60***	0.67***	0.61***	0.45*	0.18	0.39*
BMI	0.67***	0.45*	0.58***	0.39	0.04	0.33*	0.57***	0.64***	0.58***	0.45*	0.02	0.36**
Triceps sk.	0.35*	0.34	0.35	0.39	–0.16	0.23	0.45***	0.43*	0.44***	0.41	–0.004	0.32
Biceps sk.	0.39*	0.25	0.34	0.06	0.26	0.28	0.39*	0.30	0.36***	0.13	0.10	0.18
Subscapular sk.	0.31	0.27	0.29	0.37	–0.15	0.18	0.46***	0.44**	0.45***	0.53**	0.14	0.42***
Suprailiac sk.	0.24	0.03	0.15	0.38	0.03	0.23	0.37*	0.22	0.31*	0.36	0.26	0.30
Abdominal sk.	0.26	0.10	0.22	0.34	–0.21	0.10	0.23	0.14	0.21	0.49*	–0.23	0.23
Thigh sk.	0.17	–0.02	0.08	0.25	–0.02	0.25	0.36*	0.18	0.27	0.33	0.04	0.31
Shoulder cir.	0.62***	0.29	0.48***	0.61***	0.29	0.48***	0.57***	0.46*	0.52***	0.74***	0.31	0.59***
Abdominal I cir.	0.60***	0.50**	0.57***	0.42	0.21	0.40**	0.55***	0.49**	0.54***	0.48*	0.16	0.42***
Hip cir.	0.49**	0.34	0.44***	0.37	–0.11	0.20	0.41*	0.52**	0.44***	0.41	–0.06	0.27
WHR	0.41*	0.38	0.39***	0.20	0.24	0.29	0.44**	0.20	0.36***	0.28	0.16	0.27

* $p < 0.05$; ** $p < 0.02$; *** $p < 0.01$

Table 6. Correlation coefficient between blood glucose and anthropometric measurements

	Obese sedentary control			Obese trained dieters		
	1	2	5 (Total)	3	4	6 (Total)
No.	34	23	57	18	17	35
Height	–0.26	–0.24	–0.25	0.34	0.17	0.17
Weight	0.20	–0.07	0.01	–0.17	0.07	0.08
BMI	0.26	–0.01	0.06	–0.22	0.03	0.05
Triceps sk.	0.19	0.08	0.12	–0.11	0.07	0.08
Biceps sk.	0.08	–0.17	–0.04	–0.39	0.14	0.06
Subscapular sk.	–0.06	0.21	0.10	0.36	–0.32	–0.09
Suprailiac sk.	0.12	–0.05	0.10	–0.27	0.23	0.09
Abdominal sk.	0.17	–0.04	0.11	–0.25	0.03	0.07
Thigh sk.	0.34	–0.08	0.04	–0.15	0.04	0.04
Shoulder cir.	0.29	0.21	0.21	–0.18	0.17	0.09
Abdominal I cir.	0.26	0.14	0.17	–0.34	0.25	0.08
Hip cir.	0.26	–0.02	0.12	–0.13	–0.18	–0.06
LBM	0.12	–0.14	–0.06	–0.05	0.11	0.11
WHR	0.13	0.21	0.14	–0.44	0.36	0.17

women had a wider variation of values than those found in obese treated women whose body fat distribution was more homogenous. Reduction in some regions of trunk fat weregreater than that of the extremities. Moreover, the difference in the correlation between abdominal subcutaneous fat and abdominal circumference with the body weight suggests an increased mobilization of the deep abdominal fat depot as a result of caloric restriction and exercise. In this context the antilipolytic effect of catecholamine was reported to be less pronounced in omental than in subcutaneous fat cells, especially during fasting (22). On the other hand, in this study the WHR as a useful parameter defining regional obesity associated with metabolic abnomalities was not significantly correlated with the body weight in either group, in spite of recording lower values in the younger treated females compared to their control counterparts, and was negatively correlated in the older treated group. LBM in our studied sample were similar, both groups were highly correlated regarding weight. In programs combining diet with exercise some investigators reported a high percent of fat loss in women whose weight loss average ~ 1 kg/week (23, 24). Preservation of LBM in our studied sample might have been due to the preservative effect of mild exercise they performed.

The association between blood pressure and the different body fat regions was differently affected by age. There was a positive correlation between systolic blood pressure and body weight, BMI, arm skinfolds, shoulder, abdominal hip circumferences and WHR in the younger sedentary obese women. All these correlations were absent in the similar age group of obese women under the weight control program, except that of the shoulder circumference which retained its high positive significant correlation. Comparing the diastolic blood pressure in the same age group, we found that it correlated with most of the obesity indices of the control obese women, while the younger women under the program retained a weaker association between diastolic blood pressure and body weight, BMI, trunk skinfolds and abdominal circumference, and none with the gluteofemoral region and WHR. On the contrary, a high positive correlation with the shoulder circumference and subscapular skinfold was maintained. In this context, as it has been reported in the literature that hormonal aberrations accompany obesity, especially those of the adrenal cortex (25), also women with android type obesity due to hormonal influence might support our result favorably.

Findings concerning the older group were somewhat different. The systolic blood pressure of the sedentary obese women was significantly correlated with weight, BMI, and abdominal circumference. The diastolic blood pressure also correlated positively with the above parameters and was further correlated with triceps, subscapular skinfolds, shoulder and hip circumferences. No correlation of blood pressure with WHR was recorded, which is probably due to a large accumulation of fat on the hip region. The absence of any relation between both systolic, diastolic blood pressure, and the subcutaneous abdominal fat (abdominal skinfold), plus their significant correlation with the abdominal circumference denotes the close relation and role of the deep abdominal fat as a risk factor in increasing the blood pressure. It is of great interest to note that all correlations between obesity indices and systolic and diastolic blood pressure were absent in older women under the weight-control program. This suggests that older women benefited more from this program, most probably due to the change in their lifestyle in the form of physical training and caloric restriction which abolished the effect of obesity on blood pressure through improving their cardiac indices (26) and their metabolic aberrations.

It is well known that obesity is accompanied by abnormal glucose metabolism due to abnormal rise in insulin level (27, 28). To avoid hypoglycemia the body compensates by reducing the number of insulin receptors present at the cellular level (29). This explains the normal fasting blood glucose level present among our obese subjects and the absence of correlation between it and the different obesity indices. However, the mean values of fasting blood glucose were lower in the whole group of the obese trained dieters, reaching a significantly lower level in the younger age group as compared to the corresponding obese controls. This could be attributed to a direct effect of the low caloric diet consumed.

In conclusion, the data from the present study revealed the association between blood pressure, obesity, and body fat distribution. The older age group benefited more from the combination of exercise and caloric restriction in a weight-control program by improving their cardiac indices and diminishing the effect of regional fat distribution on their metabolic profile. Fat around shoulder showed high correlation with both systolic and diastolic blood pressure in the younger age group, a finding which persisted after the program. The importance of WHR as a predictor factor for cardio-vascular diseases was not well defined in this study, especially in older group. This might be due to deposition of fat on the hip region, probably due to racial influence.

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