The Relation between Visceral and Subcutaneous Fat to Bone Mass among Egyptian Children and Adolescents

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Abstract

BACKGROUND: The relation between fat distribution and bone mass is still being debated in children and adolescents.

AIM: To verify the influence of both visceral and subcutaneous fat on bone mass among Egyptian children and adolescents.

SUBJECTS AND METHODS: The study involved 78 (38 boys and 40 girls) individuals from children (42) and adolescents (36), aged 8-17 years. They were divided into 2 age groups: children group (20 boys and 22 girls) aged 8-12 years and adolescent group (18 boys and 18 girls) aged 13-17 years. Anthropometric measurements, visceral and subcutaneous fat (measured by ultrasound), body composition, BMD and BMC (Measured by DXA), were attempted.

RESULTS: Among children, significant positive correlations between visceral fat; in males; and subcutaneous fat; in females; with total BMC, BMD and its Z-score were revealed. After exclusion of age effect, the association between visceral fat in females with total BMD and its Z-score and lumbar BMD-Z-score became significant. For adolescents, no correlation was observed between either visceral or subcutaneous fat with any parameter of bone mass.

CONCLUSIONS: Visceral and subcutaneous fat had significant positive association with bone mass in children; males and females respectively. On the contrary such association disappeared during adolescence.

Introduction

Childhood and adolescence are two phases of the human development, during which the adult bone mass density is determined. Therefore, problems during this period of life could compromise bone health in adulthood [1].

In modern societies, osteoporosis is a highly occurring disease and constitutes a public health concern due to its impact on public costs [2].

The impact of body fat distribution on bone metabolism is becoming a focus of attention. In this regard, controversial issues related to obesity and bone mass have been raised, some data suggest that the type of body fat distribution, especially visceral adiposities, are linked to the secretion of proinflammatory cytokines that can act negatively on bone metabolism [3].

Indeed, data are conflicting regarding the association of visceral and subcutaneous fat in bone metabolism, with studies reporting positive, negative, or lack of association [4].

Understanding the relationship between pediatric body fat distribution and bone health is relevant for health professionals, because childhood and adolescence are two critical periods in the prevention and development of diseases in adulthood. The relationship between adipose and bone tissues is still being debated. So, the purpose of this study was to verify the interaction of visceral and subcutaneous fat with bone mass in both children and adolescents.

Subjects and Methods

Subjects

This cross-sectional study involved 78 Egyptian participants (38 boys and 40 girls) from both

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children and adolescents. Their age ranged between 8 and 17 years, with mean 12.3 $\pm$ 2.7 years. They were recruited from those attending at the DEXA Unit, The Medical Service Unit, in the National Research Centre, Egypt. All participants had a sedentary life (i.e. practicing less than 2 hours of physical activity per week and not involved in impact sports), with no co-morbidities, no history of fracture and no history of major orthopedic problems or other disorders that are known to affect bone metabolism. The participants were divided into 2 age groups: children group aged 8-12 years (20 boys and 22 girls), and adolescent group aged 13-17 years (18 boys and 18 girls). An informed written consent was obtained from all the participants and their parents. This study was approved by the Ethical Committee of the "National Research Centre".

Anthropometric measurements

Anthropometric evaluation, that included body weight, height, waist and hip circumferences, was performed for every participant, following the recommendations of the International Biological Program [5]. Body weight was determined to the nearest 0.01 kg using a Seca Scale Balance, with the subject wearing minimal clothing and with no shoes. Body height was measured to the nearest 0.1 cm using a Holtain portable anthropometer. Waist circumference was measured at the level of the umbilicus with the subject standing and breathing normally, and hip circumference was measured at the level of the iliac crest, using non-stretchable plastic tape to the nearest 0.1 cm. All circumferences were taken with the subjects standing upright, with the face directed forward and shoulders relaxed. The following adiposity indices were calculated:

- Body mass index (BMI) = weight divided/ height squared (Kg/m²).

- Waist/Hip ratio (cm/cm).

Abdominal Ultrasound (US) examination was carried out to each participant to evaluate visceral and subcutaneous fat at the umbilicus in cm. Intra-abdominal fat thickness measurement was obtained using the "Medison Sonoace X8" ultrasonography equipment. An imaging diagnosis specialist carried out the examination, using a multifrequency transducer (broadband) at 3.5 MHz, which reduces the risk of error. This transducer was transversely positioned 1 cm above the umbilical scar on the abdominal midline, without exerting any pressure over the abdomen. Subcutaneous fat tissue was measured as the distance between the skin and external face of the rectus abdominis. Visceral fat tissue was measured as the distance between the inner face of the rectus abdominis and the anterior wall of the aorta in the abdominal midline, during expiration. These parameters were based on previous methodological descriptions [6].

DEXA measurements

Body composition (total lean mass, total fat mass and abdominal fat mass in Kg), as well as, bone mineral content ("BMC" in gm), bone mineral density ("BMD" in gm/cm²) and BMD Z-score for the whole body and at lumbar spines, were measured using dual-energy DEXA (DEXA Norland XR-46 version 3.9.6, USA). The DEXA measurements were completed for the whole body, after using the participant's age, weight and height. Total body scan requires the participant to keep the right distance between his or her arms and legs according to the manufacturer's specifications [7]. The same certified technician performed all analyses using the same technique for all measurements.

Statistical analysis

Data were analyzed using the Statistical Package for Social Sciences (SPSS/Windows Version 16, SPSS Inc., Chicago, IL, USA). Statistical significance was set at $P < 0.05$. Normality of the data was verified with the Kolmogorov-Smirnov test. All the variables showed normal distribution. Parametric data were expressed as mean $\pm$ SD. Comparisons between the different variables by sex, in the 2 age groups, were analyzed using Student's t-test for independent groups. Associations between anthropometric parameters, body composition and bone data were represented as Pearson's correlation coefficients. Partial correlation test; to exclude the effect of age; was used.

Results

In children's group (aged 8-12 years, Table 1), girls were significantly older, heavier, and taller, and with larger waist circumference and more fat mass (total and abdominal) than boys. Also, bone mineral density (BMD), bone mineral content (BMC) at lumbar spines, and total BMC were significantly higher among girls than boys. However, insignificant sex differences were observed in BMI, hip circumference, waist/hip ratio, visceral and subcutaneous fat (measured by ultrasound US), BMD Z-score (total and at lumbar spines) and total BMD. In adolescents' group (aged 13-17 years, Table 2), boys had significantly higher values of waist/hip ratio and total lean mass, while girls had significantly higher values of BMD at lumbar spine. In spite of that, insignificant sex differences were observed in most anthropometric measurements, visceral and subcutaneous fat (measured by US), fat mass (measured by DEXA), total BMD and its Z-score, total BMC, BMC and BMD z-score at lumbar spine. It was evident that, there were insignificant sex differences, in the 2 age groups,

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for visceral and subcutaneous fat (cm), total BMD (g/cm^2), BMD Z-score (total and at lumbar spine).

Table 1: Sex differences in anthropometric, ultrasound and DEXA data among children (8-12 years).

	Boys (N=20)		Girls (N=22)		t-value	p
	Mean	± SD	Mean	± SD		
Age (years)	9.45	1.57	10.82	1.05	-3.28	0.002*
Weight (Kg)	43.24	15.57	56.26	19.26	-2.39	0.021*
Height (cm)	136.98	10.12	147.46	11.81	-3.07	0.004*
BMI (Kg/m²)	22.62	6.79	25.36	7.10	-1.27	0.211
WC (cm)	70.60	14.33	81.23	17.11	-2.17	0.036*
Hip C (cm)	84.55	12.73	97.41	17.96	-2.69	0.010
WHR (cm/cm)	0.82	0.06	0.83	0.07	-0.19	0.849
US thickness:						
Visceral fat (cm)	3.77	1.30	4.06	1.75	-0.61	0.544
Subcutaneous Fat (cm)	1.29	1.36	1.65	0.73	-1.10	0.278
DXA:						
Total lean mass (Kg)	31.75	6.20	26.10	7.61	2.62	0.012*
Total Fat mass (Kg)	13.94	9.91	23.43	12.40	-2.72	0.010*
Abdominal FM (Kg)	2.65	2.04	4.59	2.54	-2.70	0.010*
Lumbar BMD (gm/cm²)	0.61	0.10	0.71	0.12	-2.94	0.005*
Lumbar BMC (gm)	18.36	4.63	24.14	8.53	-2.28	0.030*
Lumbar BMD Z-score	0.08	0.57	0.10	0.43	-0.12	0.908
Total BMD (gm/cm²)	0.74	0.10	0.78	0.12	-1.14	0.263
Total BMC (gm)	1463.00	346.06	1755.18	497.35	-2.19	0.035*
Total BMD Z-score	-1.37	1.21	-1.24	1.43	-0.32	0.754

*, p< 0.05= Significant differences.

In children group, Pearson's correlation analysis demonstrated significant positive association between each of visceral and subcutaneous fat and weight, body mass index (BMI), waist circumference (WC), hip circumference, waist hip ratio (WHR), fat mass (total and abdominal), total BMD and its Z-score. Moreover, subcutaneous fat had positive association with BMC, both total and at lumbar spines, while visceral fat had positive association with BMD-Z at lumbar spines (Table 3).

Table 2: Sex differences in anthropometric, ultrasound and DXA data among adolescents (13-17 years).

Variables	Boys (N=18)		Girls (N=18)		t-value	p
	Mean	± SD	Mean	± SD		
Age (years)	14.78	1.35	14.61	1.29	0.38	0.708
Weight (Kg)	78.04	17.71	76.40	20.55	0.26	0.799
Height (cm)	165.58	8.84	161.61	6.06	1.57	0.125
BMI (Kg/m²)	28.76	7.47	29.13	7.60	-0.15	0.882
WC (cm)	90.86	14.30	87.81	16.15	0.60	0.552
Hip C (cm)	106.81	13.13	109.44	15.51	-0.55	0.585
WHR (cm/cm)	0.85	0.07	0.79	0.05	2.57	0.015*
US thickness:						
Visceral fat (cm)	4.22	1.82	3.75	1.94	0.74	0.465
Subcutaneous Fat (cm)	2.45	2.64	1.92	0.75	0.82	0.418
DXA:						
Total lean mass (Kg)	50.11	9.49	43.60	8.78	2.14	0.040*
Total Fat mass (Kg)	26.82	14.48	31.44	12.97	-1.00	0.327
Abdominal FM (Kg)	5.03	3.07	5.91	2.79	-0.90	0.374
Lumbar BMD (gm/cm²)	0.83	0.13	0.96	0.12	-2.95	0.006*
Lumbar BMC (gm)	36.23	10.46	40.69	7.66	-1.40	0.171
Lumbar BMD Z-score	-0.02	0.52	0.21	0.48	-1.40	0.171
Total BMD (gm/cm²)	0.96	0.13	0.94	0.12	0.48	0.634
Total BMC (gm)	2595.33	471.52	2522.11	361.44	0.52	0.604
Total BMD Z-score	-0.52	1.46	-0.67	1.40	0.32	0.750

*, p< 0.05= Significant differences.

For males, nearly the same correlations were observed between *visceral fat* and anthropometric measurements, fat mass, total BMD and its Z score, and BMC; total and at lumbar site, while the

subcutaneous fat had insignificant correlations with any parameters of bone mass (Table 4).

Table 3: Pearson's Correlations between visceral and subcutaneous fat, anthropometric data and BMD among total children group (N=42).

	Visceral fat		Subcutaneous Fat	
	r	p	r	p
Age (years)	0.094	0.552	0.163	0.303
Weight (Kg)	0.442	0.003**	0.592	0.000**
Height (cm)	0.004	0.981	0.313	0.043*
BMI (Kg/m²)	0.587	0.000**	0.612	0.000**
WC (cm)	0.577	0.000**	0.675	0.000**
Hip C (cm)	0.443	0.003**	0.636	0.000**
WHR (cm/cm)	0.604	0.000**	0.423	0.005**
DXA:				
Total lean mass (Kg)	0.257	0.100	0.464	0.002**
Total Fat mass (Kg)	0.554	0.000**	0.682	0.000**
Abdominal FM (Kg)	0.536	0.000**	0.683	0.000**
Lumbar BMD (gm/cm²)	0.180	0.253	0.293	0.060
Lumbar BMC (gm)	-0.060	0.743	0.574	0.001**
Lumbar BMD- Z-score	0.367	0.017*	0.207	0.188
Total BMD (gm/cm²)	0.450	0.004**	0.448	0.004**
Total BMC (gm)	0.187	0.237	0.431	0.004**
Total BMD-Z-score	0.417	0.006**	0.405	0.008**

*, p< 0.05= Significant differences; **, P < 0.05= highly significant differences.

While for females, *subcutaneous fat* had positive associations with all the parameters under study, while *visceral fat* had insignificant correlations with any parameters of bone mass, in spite of the presence of significant positive association with fat mass(total and abdominal), BMI and waist circumference.

Table 4: Pearson's Correlations between visceral and subcutaneous fat, anthropometric data and BMD among children by sex.

	Males (N= 20)				Females (N=22)			
	Visceral fat		Subcutaneous Fat		Visceral fat		Subcutaneous Fat	
	r	p	r	p	r	p	r	p
Age (years)	.323	0.165	-.005	.983	-.205	.359	.349	.111
Weight (Kg)	.638	0.002**	.436	.055	.331	.133	.886	.000**
Height (cm)	.327	0.160	.170	.473	-.256	.250	.461	.031*
BMI (Kg/m²)	.572	0.008**	.452	.045*	.596	.003*	.918	.000**
WC (cm)	.668	0.001**	.542	.014*	.531	.011*	.963	.000**
Hip C (cm)	.632	0.003**	.525	.018*	.351	.110	.912	.000**
WHR (cm/cm)	.554	0.011*	.442	.051	.634	.002*	.474	.026*
DXA:								
Total lean mass (Kg)	.476	0.034*	.254	.280	.110	.625	.778	.000**
Total Fat mass (Kg)	.691	0.001**	.592	.006*	.497	.018*	.939	.000**
Abdominal FM (Kg)	.767	0.000**	.563	.010*	.425	.049*	.977	.000**
Lumbar BMD (gm/cm²)	.396	0.084	.006	.981	.021	.925	.631	.002*
Lumbar BMC (gm)	.564	0.036*	.503	.067	-.291	.242	.475	.047*
Lumbar BMD- Z-score	.363	0.115	-.011	.962	.398	.066	.700	.000**
Total BMD (gm/cm²)	.658	0.002**	.258	.272	.318	.172	.774	.000**
Total BMC (gm)	.609	0.004**	.303	.194	-.043	.849	.628	.002*
Total BMD-Z-score	.639	0.002**	.216	.361	.288	.194	.745	.000**

*, p< 0.05= Significant differences;**, P < 0.05= highly significant differences.

Partial Correlations; to exclude the effect of age (which showed significant sex differences in the children group); between visceral and subcutaneous fat, anthropometric data and BMD among children revealed that the age had no effect on the correlations between visceral fat and bone mass for males, while it had a significant effect for females (as after exclusion of the effect of age, the positive correlation between

visceral fat and BMD (total and at lumbar site) and total BMD Z-score became significant). The age also had no effect on the correlations between subcutaneous fat and the parameters under study for either males or females (Table 5).

Table 5: Partial Correlations between visceral and subcutaneous fat, anthropometric data and BMD among children.

	Males (N= 20)				Females (N=22)			
	Visceral fat		Subcutaneous Fat		Visceral fat		Subcutaneous Fat	
	r	p	r	p	r	P	r	p
Weight (Kg)	0.430	0.142	0.763	0.002*	0.752	0.000**	0.915	0.000**
Height (cm)	-0.055	0.858	0.163	0.596	0.069	0.792	0.406	0.106
BMI (Kg/m²)	0.435	0.138	0.749	0.003*	0.850	0.000**	0.933	0.000**
WC (cm)	0.430	0.143	0.878	0.000**	0.735	0.001*	0.969	0.000**
Hip C (cm)	0.421	0.153	0.899	0.000**	0.688	0.002*	0.927	0.000**
WHR (cm/cm)	0.221	0.468	0.368	0.216	0.546	0.024*	0.642	0.005*
DXA:								
Total lean mass (Kg)	0.169	0.582	0.535	0.059	0.555	0.021*	0.825	0.000**
Total fat mass (Kg)	0.514	0.073	0.904	0.000**	0.821	0.000**	0.936	0.000**
Abdominal FM (Kg)	0.595	0.032*	0.923	0.000**	0.657	0.004*	0.980	0.000**
Lumbar BMD (gm/cm²)	0.459	0.114	0.293	0.332	0.434	0.082	0.615	0.009*
Lumbar BMC (gm)	0.552	0.051	0.451	0.122	-0.076	0.773	0.353	0.165
Lumbar BMD- Z-score	0.472	0.103	0.313	0.299	0.589	0.013*	0.694	0.002*
Total BMD (gm/cm²)	0.651	0.016*	0.297	0.325	0.682	0.003*	0.780	0.000**
Total BMC (gm)	0.579	0.038*	0.390	0.187	0.472	0.056	0.667	0.003*
Total BMD-Z-score	0.623	0.023*	0.325	0.278	0.728	0.001*	0.785	0.000**

*, p< 0.05= Significant differences; **, P < 0.05= Highly significant differences.

In adolescents' group, visceral fat only showed positive association with the investigated anthropometric measurements and fat mass (total and abdominal) (Table 6). For females only, visceral and subcutaneous fat had nearly the same associations with the anthropometric measurements and fat mass (total and abdominal). For males, subcutaneous fat had no association with any parameter under study, while visceral fat had significant positive correlations with BMI and abdominal fat mass (Table 7). Either visceral or subcutaneous fat had no association with any parameter of BMD, BMC, or BMD-Z score (either total or at lumbar site) in this age group; total and by sex (table6, 7). Partial correlation; to exclude the effect of age; was done and revealed the same results (not included).

Table 6: Correlations between visceral and subcutaneous fat, anthropometric data and BMD among adolescents (N=38).

	Visceral fat		Subcutaneous Fat	
	r	p	r	p
Age (years)	-0.395	0.021*	-0.153	0.379
Weight (Kg)	0.555	0.001**	0.126	0.472
Height (cm)	-0.385	0.025*	0.115	0.512
BMI (Kg/m²)	0.674	0.000**	0.093	0.593
WC (cm)	0.656	0.000**	0.112	0.521
Hip C (cm)	0.546	0.001**	0.087	0.620
WHR (cm/cm)	0.555	0.001**	0.094	0.592
DXA:				
Total lean mass (Kg)	0.227	0.196	0.149	0.392
Total Fat mass (Kg)	0.575	0.000**	0.057	0.749
Abdominal FM (Kg)	0.642	0.000**	0.060	0.731
Lumbar BMD (gm/cm²)	-0.148	0.405	-0.059	0.736
Lumbar BMC (gm)	-0.261	0.156	-0.071	0.699
Lumbar BMD Z-score	-0.023	0.899	0.145	0.405
Total BMD (gm/cm²)	0.097	0.585	0.041	0.816
Total BMC (gm)	0.025	0.888	0.037	0.832
Total BMD Z-score	0.155	0.382	0.094	0.592

*, p< 0.05= Significant differences; **, p< 0.05= Highly significant differences.

Discussion

In both children and adolescents, fat deposition; either visceral or subcutaneous; is related to the development of some diseases including; dyslipidemias, high blood pressure, impaired glucose tolerance, insulin resistance and cardiovascular risk factors [8, 9]. However, little is known regarding the relation between the distribution of adipose tissue; in terms of visceral and subcutaneous adipose tissue compartments; and bone fragility [10].

Table 7: Correlations between visceral and subcutaneous fat, anthropometric data and BMD among adolescents.

	Males(N=18)				Females(N=18)			
	Visceral fat		Subcutaneous Fat		Visceral fat		Subcutaneous Fat	
	r	p	r	p	r	p	r	p
Age (years)	-0.402	0.110	-0.147	0.574	-0.431	0.084	-0.336	0.172
Weight (Kg)	0.353	0.165	0.016	0.950	0.719	0.001*	0.522	0.026
Height (cm)	-0.716	0.001*	0.150	0.565	-0.074	0.778	-0.234	0.351
BMI (Kg/m²)	0.569	0.017*	-0.047	0.859	0.787	0.000**	0.647	0.004*
WC (cm)	0.440	0.077	-0.041	0.875	0.830	0.000**	0.601	0.008*
Hip C (cm)	0.399	0.113	-0.018	0.946	0.694	0.002*	0.528	0.024*
WHR (cm/cm)	0.334	0.190	-0.070	0.789	0.869	0.000**	0.599	0.009*
DXA:								
Total lean mass (Kg)	-0.218	0.400	0.061	0.817	0.619	0.008*	0.339	0.169
Total Fat mass (Kg)	0.489	0.055	-0.049	0.858	0.757	0.000**	0.640	0.004*
Abdominal FM (Kg)	0.675	0.003*	-0.027	0.919	0.674	0.003*	0.551	0.018*
Lumbar BMD (gm/cm²)	-0.178	0.495	-0.005	0.985	-0.033	0.899	0.022	0.931
Lumbar BMC (gm)	-0.420	0.119	-0.032	0.909	-0.041	0.881	-0.044	0.868
Lumbar BMD- Z-score	-0.036	0.890	0.244	0.346	0.034	0.898	0.052	0.836
Total BMD (gm/cm²)	-0.087	0.741	-0.035	0.894	0.253	0.326	0.259	0.298
Total BMC (gm)	-0.177	0.498	0.004	0.987	0.234	0.367	0.103	0.685
Total BMD-Z-score	0.003	0.992	0.045	0.865	0.284	0.269	0.271	0.276

*, p< 0.05= Significant differences; **, p< 0.05= highly significant differences.

Regional adiposity can be assessed by using anthropometric data and imaging techniques [11, 12]. Among imaging techniques, Ultrasonographic assessment has attracted a considerable attention, as it combines safety, cost-effectiveness, accuracy [13] and with effectiveness, in the quantification of visceral fat, similar to that of computed tomography [14].

Sex differences in depot-specific adiposity in childhood have not been clearly delineated, and results are not consistent across studies. The present study revealed insignificant sex differences, in the 2 age groups; 8- 17 years; for visceral and subcutaneous fat (cm), and bone mass [total BMD (g/cm²), BMD Z-score ; total and at lumbar spine]. This was reported previously by *Huang* et al [15] among children. Norris et al [16], also studied bone mass acquisition between the ages of 9 and 18 years in urban South Africa, and reported no sex significant differences in lumbar spine bone mineral content. On contrary to that, other studies [17-19] concluded that females have significant more abdominal subcutaneous fat throughout childhood and adolescence. *Owens* et al [20]; Lee et al [21] and Le et al [22] also found that males typically have more visceral fat than females, yet the age at which this divergence begins differs. Failure to control for age, ethnicity, and total body fat, and small samples with limited range of age or adiposity, may account for these contradictory findings [23].

Most studies examined the association between adiposity and BMD in adult men and women [24, 25], however, few studies dealt with this association in children and adolescents. The current study revealed significant positive relationship between developing bone and obesity in children group. It reported positive significant associations between visceral and subcutaneous fat and total bone mass (BMD and its Z-score). This result confirmed with some previous studies [24-27]. Wang et al. [24]

suggested that the relation between adiposity and BMD may be confounded by BMI and age. Pollock et al [27] accepted view that obesity is beneficial to the growing skeleton. Ducher et al [26] reported greater bone mass in children and adolescents who are overweight compared with healthy weight. Because children who are overweight compared with healthy weight children of the same age are generally further advanced in maturation, their skeletal development is likewise more advanced, because of increased hormonal activity, than their healthy weight peers. In addition, the metabolic effects of obesity could have an impact on bone development. Semiz & his colleagues [28], also reported a significant correlation, in Turkish children, between both visceral and subcutaneous fat and WC, but not with WHR. Reinehr & Wunsch, [29], reported that BMI, in children, was significantly correlated to the Ultrasonographic measurements of intra-abdominal fat mass. kytnarova et al. [30], reported that these associations differ according to sex. They found a significant dependence between intra-abdominal fat measured by ultrasound and WHR in boys, but not in girls. On contrary, other studies conclude that obesity is linked to lower bone mass or that extra weight from fat mass had no effect on bone mass [31].

There were significant positive associations between each of visceral and subcutaneous fat and BMD in children in the present study. However, these associations were not observed in adolescents. These contrasting findings may reflect changes in the association between fat and bone around the time of puberty [32].In agreement with these results, Viljakainen & his colleagues [33], in Finland, have studied an age group of 7-19 years, and concluded that in children and adolescents. On the other hand, *Pollock et al.* [34], in USA, conducted a study on age group 14-18 years, and found an inverse relationship between visceral fat and bone mass. However, they did not observe a significant relationship between subcutaneous adipose tissue and bone mass. While, *Raquel et al* [35], in Brazil, conducted a study on an age group of 14-18 years, and reported that, only in boys, visceral fat is a negative predictor of lumbar and total bone mineral density (g/cm² and Z-score). Whereas; in girls; bone mineral density (z-score) was positively associated with subcutaneous fat. Russell et al [36]; in Harvard; regarding age group 12-18 years, concluded that obese girls with higher visceral fat compared to subcutaneous fat were likely to have lower bone density than those with more subcutaneous fat than visceral fat.

Another significant finding in this study was that the influence of adiposity on bone mass may depend on the manner in which the fat mass accumulates visceral in males versus subcutaneous in females. It reported positive significant associations between visceral fat and total bone mass (BMD and its Z-score, BMC) for male children, and between subcutaneous fat and bone mass; total and at lumbar spines; for female children. The age had no effect on these correlations. In adolescents' group, either visceral or subcutaneous fat had no association with bone mass; total and by sex.

Reviewing the literatures, the association between both visceral and subcutaneous adipose tissues and bone mass is greatly variable. Both negative [37] and positive [38] associations between subcutaneous adipose tissue and bone mass have been reported. Gilsanz et al [39] confirmed the positive relationship between subcutaneous fat and bone mass in adolescent girls and young women, but Farr et al [40] showed evidence of a weak positive association for subcutaneous fat.

Our data confirms the hypothesis that the different distributions of abdominal visceral and subcutaneous adipose tissue may have different influences on trabecular BMD. A study of Gilsanz et al [39] suggested subcutaneous fat is beneficial to the trabecular BMD of lumbar spine .

Finally, it was concluded that significant positive associations between each of visceral and subcutaneous fat and BMD; in children; was detected; with stronger association with subcutaneous fat in females and visceral fat in males; while this association disappeared in adolescents.

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