ARTICLE ORIGINAL / ORIGINAL ARTICLE

BONE MASS IN A GROUP OF LEBANESE GIRLS FROM BEIRUT AND FRENCH GIRLS FROM ORLEANS

http://www.lebanesemedicaljournal.org/articles/59-3/original4.pdf

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El Hage R, Jacob C, Moussa E, Jaffré C, Baddoura R. Bone mass in a group of Lebanese girls from Beirut and French girls from Orléans. J Med Liban 2011 ; 59 (3) : 131-135.

ABSTRACT • AIM OF THE STUDY : To compare bone mineral content (BMC) and bone mineral density (BMD) in a group of Lebanese girls from Beirut and French girls from Orléans.

METHODS : This study included 26 French adolescent girls (15.3 ± 0.7 years old) and 24 maturation-matched (15.4 ± 1.1 years old) Lebanese adolescent girls. BMC, BMD at the whole body (WB) and body composition (lean mass and fat mass) were assessed by dual-energy X-ray absorptiometry (DXA). Calculations of the bone mineral apparent density (BMAD) and the ratio BMC/height were completed for the WB. Weight and height were similar in the two groups.

RESULTS : Lean mass was higher in French girls compared to Lebanese girls ($p < 0.05$). In the whole population, lean mass was a positive determinant of BMC and BMD. French girls displayed higher values of BMC, BMD, BMC/height and BMAD than Lebanese girls ($p < 0.05$). Finally, BMC and BMD remained higher in French girls in comparison to Lebanese girls even after adjusting for lean mass.

CONCLUSION : In this study group, Lebanese girls have lower BMC and BMD in comparison to French girls.

El Hage R, Jacob C, Moussa E, Jaffré C, Baddoura R. Masse osseuse chez des adolescentes libanaises de Beyrouth et françaises d'Orléans. J Med Liban 2011 ; 59 (3) : 131-135.

RÉSUMÉ• OBJECTIF DE L'ÉTUDE : Comparer les valeurs du contenu minéral osseux (CMO) et de la densité minérale osseuse (DMO) chez des adolescentes libanaises de Beyrouth et des adolescentes françaises d'Orléans.

MÉTHODES : Vingt-six adolescentes françaises (15,3 ± 0,7 ans) et 24 adolescentes libanaises (15,4 ± 1,1 ans) ont participé à cette étude. Le CMO, la DMO et la composition corporelle (masse maigre et masse grasse) ont été mesurés par absorptiométrie biphotonique à rayons X (DXA) sur le corps entier. La densité minérale osseuse apparente (DMOA) et le rapport CMO/taille du corps entier ont été calculés. Il n'y avait pas de différences significatives au niveau du poids et de la taille entre les deux groupes.

RÉSULTATS : La masse maigre était supérieure chez les filles françaises par rapport aux filles libanaises ($p < 0,05$). Dans la population entière, la masse maigre était un déterminant positif du CMO et de la DMO. Les adolescentes françaises ont présenté des valeurs du CMO, de la DMO, du rapport CMO/taille et de la DMOA supérieures à celles des adolescentes libanaises ($p < 0,05$). Les valeurs du CMO et de la DMO chez les adolescentes françaises étaient supérieures à celles des adolescentes libanaises même après ajustement pour la masse maigre.

CONCLUSION : Dans le groupe étudié, les adolescentes libanaises ont des valeurs du CMO et de la DMO inférieures à celles des adolescentes françaises.

INTRODUCTION

Bone mineral content (BMC) and bone mineral density (BMD) acquired during childhood and adolescence are key determinants of adult bone health [1-2]. In fact, BMC and BMD attained by young subjects at the end of their second decade of life are considered to be determinants of their risk of osteoporotic fractures in later life [1-2]. The factors contributing to the large variance in BMC and BMD at the end of the second decade of life are genetics, race, gender, dietary intakes, endocrine factors, mechanical factors (e.g. practicing impact sports), the exposure to deleterious influences and ethnicity [3-4]. Interestingly, El-Hajj Fuleihan et al. [5] have previously shown that BMD is slightly lower in Lebanese adults (aged 25-35) as compared to western standards. In this study, we aimed to verify whether or not such differences are present in adolescents. To do so, we compared BMC and BMD in a group of Lebanese and French adolescent girls.

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METHODS

Subjects and study design

The Lebanese girls were recruited from two private high schools in Beirut, Lebanon, and the French girls were recruited from two public high schools in Orléans, France. Inclusion criteria were being post-menarcheal (at least one year of regular menstrual cycles) girls from 14 to 17 years of age with no diagnosis of comorbidities and no history

of fracture. They were non-smokers and had no history of major orthopaedic problems or other disorders known to affect bone metabolism. Moreover, girls participating in this study were not pregnant, unveiled and were not taking hormonal contraceptives for the last six months. In this study, the number of years since menarche was considered as a maturation index (MI). Girls were divided into two groups (French and Lebanese). An informed written consent was obtained from the children and their parents. This study was approved by the University of Balamand Ethics Committee (Tripoli, Lebanon) and the Regional Ethics Committee (Orléans, France).

Anthropometry

Body height was measured with a wall-mounted stadiometer in the upright position to the nearest 0.1 cm. Body mass was determined using an electronic scale with a precision of 100 g, and BMI was calculated as body weight divided by height squared (kg/m^2). Body composition (lean mass, fat mass and fat mass percentage) was measured by dual-energy X-ray absorptiometry (DXA). In the Lebanese laboratory (using Hologic QDR-4500W; Waltham, Mass., USA), the in vivo coefficients of variation were 1.13 and 0.54% for fat and lean mass, respectively [6]. In the French laboratory (using also Hologic QDR-4500W; Waltham, Mass., USA), the in vivo coefficients of variation were 4.2 and 0.48% for fat and lean mass, respectively.

Bone measurements

Bone mineral content (BMC, in g), bone mineral area (BMA, in cm^2) and bone mineral density (BMD, in g/cm^2) were determined for each individual. The DXA measurements were completed for the whole body (WB) using the instrument previously described. The coefficients of variation were < 1% for BMC and BMD in both laboratories [6-7]. Bone mineral apparent density (BMAD g/cm^3), an estimate of volumetric bone density, was calculated as previously described [8]. The BMAD for WB is calculated as follows: BMC ÷ [BMA^2 ÷ Body Height]. The ratio BMC/Height was calculated to adjust for whole body bone size [9]. Finally, we adjusted the DXA measurements for lean mass and physical activity as these parameters are correlated with bone values [10-11].

Daily calcium intake

The estimation of the daily calcium intake was based on a frequency questionnaire [12]. Selection of items was based on the food composition diet, frequency of use, and relative importance of food items as a calcium source. The total number of food items was 30. The questionnaire included : milk and dairy products, including calcium-enriched items such as yoghurt, cheese and chocolate. Items such as eggs, meat, fish, cereals, bread, vegetables and fruits were also included. Adequacy of calcium in the subjects was assessed using the adequate intake guidelines of 1,300 mg of calcium.

Physical activity

Exercise frequency was assessed from a questionnaire inquiring about the number of hours spent on sports per week.

Statistical analysis

Basic data are presented as mean ± standard deviation (SD) (Table I) or mean ± standard error (SE) (Table IV). Comparisons between the French and the Lebanese girls were made after checking for Gaussian distribution. If Gaussian distribution was found, parametric unpaired t tests were used. In other cases, Mann-Whitney U tests were used. Associations between anthropometrics, daily calcium intake, physical activity and bone data were given as Pearson correlation coefficients (Table II). Multiple linear regression analysis models were used to test the relationship between whole-body BMD with lean mass, physical activity and fat mass percentage (Table III). DXA values were compared after adjustment for lean mass, fat mass percentage, maturation index, daily calcium intake and physical activity using a one-way analysis of covariance (ANCOVA). The difference was considered statistically significant at $p < 0.05$. Data were analyzed using NCSS (2001).

RESULTS

Clinical characteristics of the subjects

Clinical characteristics of the adolescent girls are displayed in Table I. Age, maturation index (MI), height,

TABLE I

CLINICAL CHARACTERISTICS AND BONE MINERAL VALUES IN THE FRENCH AND THE LEBANESE ADOLESCENT GIRLS

	French (n = 26)	**Lebanese** (n = 24)
Age (years)	15.3 ± 0.7	15.4 ± 1.1
MI (years)	2.8 ± 1.2	3.0 ± 1.4
Height (cm)	163.2 ± 6.3	160.1 ± 5.3
Weight (kg)	55.9 ± 6.2	57.9 ± 9.1
BMI (kg/m^2)	20.9 ± 1.6*	22.5 ± 3.1
Lean mass (kg)	40.4 ± 4.1**	37.4 ± 3.4
Fat mass (kg)	13.3 ± 2.6**	18.8 ± 6.1
Fat mass (%)	23.8 ± 3.0***	31.4 ± 6.4
Physical activity (h/week)	5.7 ± 3.8**	3.0 ± 1.5
DCI (mg/day)	980 ± 365	750 ± 278
BMC (g)	2,120 ± 242***	1,772 ± 187
BMD (g/cm^2)	1.104 ± 0.064***	0.993 ± 0.065
BMC/Height (g/cm)	13.0 ± 1.1***	11.1 ± 1.1
BMAD (g/cm^3)	0.094 ± 0.006*	0.089 ± 0.006

Values are means ± SD — **MI**: Maturation Index (years since menarche)
BMI : body mass index — **DCI** : daily calcium intake
BMC : bone mineral content — **BMD** : bone mineral density
BMAD : bone mineral apparent density
*** French significantly different than Lebanese $p < 0.001$
** French significantly different than Lebanese $p < 0.01$
* French significantly different than Lebanese $p < 0.05$.

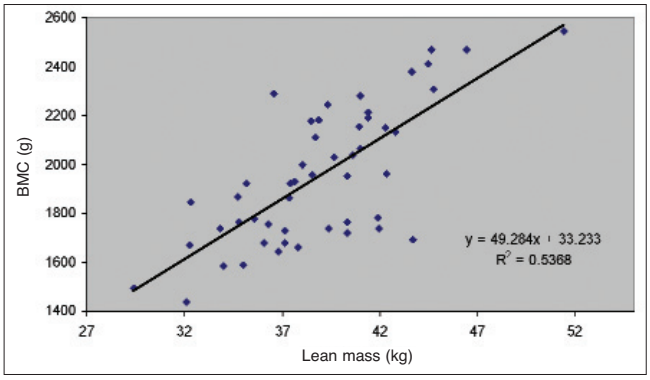

FIGURE 1. Relation between lean mass and bone mineral content.

weight and daily calcium intake were not significantly different between the two groups. However, BMI, lean mass, fat mass, fat mass percentage and physical activity (h/week) were significantly different between the two groups ($p < 0.05$). Only 7% of the Lebanese girls and 35% of the French girls met the adequate daily calcium intake recommendation of 1,300 mg/day.

Crude bone measurements

French girls had higher BMC, BMD and BMC/Height values than Lebanese girls ($p < 0.001$). Moreover, French girls displayed higher BMAD values in comparison to Lebanese girls ($p < 0.05$) (Table I).

Correlations between age, maturation index, anthropometrics, daily calcium intake, physical activity and bone data in the whole population

Age was only related to BMAD ($p < 0.01$). Height, weight, lean mass and physical activity were positively correlated to BMC and to the ratio BMC/Height ($p < 0.05$). Lean mass and physical activity were positively correlated to BMD ($p < 0.01$) while fat mass percentage was negatively associated with BMD ($p < 0.05$). Figure 1 shows the relation between lean mass and BMC. Daily calcium intake was not correlated to bone data. Weight, BMI, fat mass and fat mass percentage were negatively associated with BMAD ($p < 0.01$) while physical activity was positively associated to BMAD ($p < 0.05$) (Table II). Finally, in a multivariate analysis, lean mass, physical activity and fat mass percentage explained 30% of the BMD variance (Table III).

TABLE III

MULTIPLE LINEAR REGRESSION ANALYSIS MODEL

Dependent variable BMD ($r^2 = 0.30$)			
	Coefficient	SE	*p*
Constant	0.837	0.107	***
Lean mass (kg)	0.007	0.002	**
Physical activity (h/week)	0.007	0.003	*
Fat mass (%)	– 0.351	0.166	*

BMD : bone mineral density **SE**: standard error
*** $p < 0.001$ ** $p < 0.01$ * $p < 0.05$

Adjusted bone mineral values

After adjustment for either lean mass, fat mass percentage, maturation index, daily calcium intake or physical activity, BMC, BMC/Height and BMD remained higher in French girls in comparison to Lebanese girls ($p < 0.001$). BMAD remained higher in French girls in comparison to Lebanese girls after adjustment for either lean mass, daily calcium intake or maturation index ($p < 0.05$).

DISCUSSION

This study conducted on 26 French adolescent girls and 24 maturation-matched Lebanese girls shows that Lebanese girls have lower WB BMC and BMD compared to French girls even after adjusting for lean mass.

In this study, BMC, BMD, BMC/Height and BMAD were significantly higher in French girls in comparison to Lebanese girls. These results seem coherent since Lebanese adults have lower BMD compared to American and Qatari adults [5, 13]. In general, there is an established eth-

TABLE II

CORRELATIONS BETWEEN AGE, MATURATION INDEX, ANTHROPOMETRICS, DAILY CALCIUM INTAKE, PHYSICAL ACTIVITY AND BONE DATA

	BMC (g)	**BMC/Height** (g/cm)	**BMD** (g/cm²)	**BMAD** (g/cm³)
Age (years)	0.03	0.02	0.19	0.40**
MI (years)	– 0.16	– 0.16	– 0.10	0.06
Height (cm)	0.61***	0.41**	0.27	– 0.07
Weight (kg)	0.41**	0.33*	0.08	– 0.38**
BMI (kg/m²)	0.09	0.13	– 0.06	– 0.38**
Lean mass (kg)	0.73***	0.62***	0.40**	– 0.14
Fat mass (kg)	– 0.02	– 0.05	– 0.23	– 0.44**
Fat mass (%)	– 0.20	– 0.20	– 0.32*	– 0.38**
Physical activity (h/week)	0.32*	0.33*	0.41**	0.34*
DCI (mg/day)	0.15	0.09	0.07	– 0.02

BMC : bone mineral content **BMD** : bone mineral density **BMAD** : bone mineral apparent density **MI**: maturation index (years since menarche)
BMI : body mass index **DCI** : daily calcium intake *** $p < 0.001$ ** $p < 0.01$ * $p < 0.05$

TABLE IV

BONE MINERAL VALUES ADJUSTED FOR LEAN MASS AND PHYSICAL ACTIVITY IN THE FRENCH AND THE LEBANESE ADOLESCENT GIRLS

	Adjusted for lean mass		Adjusted for physical activity	
	FRENCH (n = 26)	LEBANESE (n = 24)	FRENCH (n = 26)	LEBANESE (n = 24)
BMC (g)	2062 ± 31***	1834 ± 32	2111 ± 42***	1781 ± 44
BMD (g/cm^2)	1.098 ± 0.012***	0.999 ± 0.013	1.098 ± 0.012***	0.999 ± 0.013
BMC/Height (g/cm)	12.7 ± 0.1***	11.3 ± 0.1	12.9 ± 0.2***	11.1 ± 0.2
BMAD (g/cm^3)	0.095 ± 0.001**	0.088 ± 0.001	0.093 ± 0.001	0.090 ± 0.001

Values are means ± SE **BMC** : bone mineral conten **BMD** : bone mineral density *** French significantly different than Lebanese $p < 0.001$
** French significantly different than Lebanese $p < 0.01$

nic difference in BMC and BMD [9]. In our study group, Lebanese girls had lower lean mass and were less active than French girls. However, after adjusting for these variables, BMC, BMC/Height and BMD remained higher in French girls compared to Lebanese girls suggesting that other factors are also responsible for these ethnic differences. Concerning this, vitamin D insufficiency is common among Lebanese children and adolescents [14-15]. The latter may contribute to explain partially the differences in BMC and BMD between French and Lebanese girls. However, genetic factors and misidentified parameters related to nutrition and to lifestyle cannot be excluded.

In this report, weight, height and lean mass were positively related to BMC. These results are in line with those of many previous studies [6, 7, 11, 15-17]. In addition, lean mass was a positive determinant of BMD while fat mass percentage was a negative determinant of BMD after controlling for lean mass and physical activity. Our results are in accordance with those of two previous reports [18-19].

Lean mass and weight were positively correlated to the ratio BMC/Height. The latter reinforces the hypothesis that states that increased body weight and lean mass during adolescence are associated with higher BMC for height [17].

Weight, BMI and fat mass were all negatively related to BMAD. These results are in conformity with those reported by Rocher et al. [16] who showed that obese children had lower BMAD in comparison with controls.

In our study, duration of physical activity (h/week) was correlated to BMC, BMD, BMC/Height and BMAD. These results are in compliance with those of a recent study [10]. It is well established that physical activity practice during adolescence is a positive determinant of BMC and BMD [3, 7, 10-11]. In fact, mechanical stresses are a major determinant of bone modeling and remodeling, and it is generally believed that osteocytes are the major mechanosensory bone cell [20-21]. The production by the osteocytes of mediators such as prostaglandins and nitric oxide stimulate the production of other cytokines and growth factors such as insulin like growth factor [20-21].

Finally, daily calcium intake (750 mg) in the Lebanese girls was below the daily requirements in this age group (1300 mg) [12]. These results are in line with two studies which measured daily calcium intake in Lebanese adolescent girls [14, 22]. Also, we showed a lack of correlation between daily calcium intake, on one hand, and BMC and BMD, on the other hand, in the whole population. This result is in accordance with those of several studies conducted on adolescent girls [6-7, 15]. In fact, genetic factors are the strongest predictors of bone mass accounting for 60-80% of its variance while other lifestyle factors such as nutrition, exercise, and smoking explain an additional 20-40% of bone mass variance [3-4].

Some limitations of this study deserve comment. Firstly, the cross-sectional nature of the study is a limitation because it cannot evaluate the confounder variables. Secondly, there are well-known difficulties in assessing diet and physical activity using self-reported questionnaires. Lastly, the small number of subjects is also a limitation. However, it's the first study that aimed at comparing BMC and BMD in a group of Lebanese and French adolescent girls.

In conclusion, this study suggests that Lebanese girls have lower BMC, BMD, BMC/Height and BMAD in comparison to French girls. Moreover, these differences remained significant between the two groups after adjustment for either lean mass, daily calcium intake or maturation index. Further investigations are necessary to better understand the causes responsible for the low BMC and BMD in Lebanese adolescents. However, Lebanese girls should take more care of all the factors able to influence BMC and BMD such as physical activity, vitamin D, calcium intake, protein intake and soft drinks consumption.

ACKNOWLEDGMENTS

This study was supported by a grant from the Research Council of the University of Balamand, Lebanon.

CONFLICTS OF INTEREST: none

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