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Bone mineral density, body composition, and food intake of adolescent runway models

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Abstract

Objective: To evaluate the bone mineral density (BMD) and to relate it to the food intake and body composition of adolescent runway models.

Methods: Cross-sectional study evaluating 33 models and 33 non-models aged from 15 to 18 years, paired by age and body mass index (BMI). BMD of spine (L1-L4) was evaluated using the dual-energy X-ray absorptiometry technique (Lunar® DPX Alpha), and body composition was assessed by means of plethysmography. Food intake was evaluated by a 3-day-food record.

Results: The subjects' mean age was 16.75±1.04 years, and 24% had BMI below ideal value for their age. BMD values (g/cm^2) were similar between models (1.108±0.080) and non-models (1.096±0.102) ($p > 0.05$), and 6% of the participants had low BMD for age. We found that the mean energy intake was lower among models as compared to non-models (1,480.93±582.95 vs. 1,973.00±557.63 kcal) ($p < 0.05$) and that most of the adolescents in both groups presented an inadequate consumption of micronutrients, with emphasis to the low calcium intakes. There was only significant correlation between BMD and lean body mass (kg) ($r = 0.362$ for models and $r = 0.618$ for non-models) ($p < 0.05$).

Conclusion: Although no association was found between BMD, BMI, and intake of nutrients wich are important for the bone mineralization process, inadequacies of food intake have an adverse influence on the acquisition of bone mass, which is more effective at this stage of life.

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Introduction

Osteoporosis and osteopenia, which used to be investigated only in the adult and elderly population, have been raising the interest of pediatricians, since bone mineral density (BMD) in adulthood is directly related to the bone mass acquired during adolescence.[1,2] At this stage of life, there is a 40 percent increase in the bone mass and there is also a peak of bone mass, which will be a determinant factor for the occurrence of fractures and for future bone health.[1]

Individuals acquire bone mass up to the middle of the second decade of life, but adolescence is certainly a critical period. A U.S. study involving 247 adolescent and adult women from 11 to 32 years old found that approximately 90% of the bone mineral content is acquired up to the age of 17 years, 95% up to 19 years, and 99% at the age of 22 years.[3]

It is important to mention that several factors interfere with bone mass acquisition, and such factors can be divided

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This study was conducted at the Adolescent Care and Support Center, Department of Pediatrics, Universidade Federal de São Paulo (UNIFESP), São Paulo, SP, Brazil.

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into intrinsic and extrinsic aspects. Among the former are genetic and hormonal factors, as well as those related to gender and ethnicity, accounting for almost 80% of the bone mass content. On the other hand, the extrinsic factors include nutritional and mechanical aspects, as well as those related to physical activity. Within such a context, it is possible to detect that Caucasian, female adults, with low weight, who have late puberty, or who are little physically active are more prone to have lower bone mass.[2] However, research on the factors that have an influence on bone remodeling during adolescence is in its initial steps in spite of the relevance of the environmental factors, mainly the nutritional status, for adequate bone acquisition.

Brazilian studies conducted with the purpose of assessing adolescent professional models found that 25% of them had low weight and the remaining were within the (low) threshold range of normality, meaning that bone mass content might be impaired considering the relation between body mass and bone health.[4,5] However, there is a shortage of studies associating these population's slimness with bone health.

In addition to body mass, it is important to highlight the relevant interrelation between dietary intake and bone mass in terms of nutritional aspects. According to the literature, low intake of energy, minerals, such as calcium,[6] magnesium, and phosphorus,[2,7] and vitamins D and K[8,9] is associated with lower bone mass increase. Furthermore, excessive intake of proteins[10] and sodium[11] also has a negative effect on bone health, especially due to impairment caused to the metabolism of nutrients that are essential for the bones, mainly calcium and vitamin D.[12]

Adults' bone mass is assessed based on the comparison of BMD values with the mean values found in healthy young individuals (T score). Values are considered normal when they are between 0 and 1 standard deviation (SD).[13] In pediatrics, however, such values must be adjusted according to age and sex (z score) and the threshold values for osteopenia and osteoporosis have not been set yet. At this stage of life, low BMD is diagnosed when the z score is below -2 SD.[14,15] The relevance of this assessment in pediatrics was corroborated by Golding et al., who assessed 90 children and adolescents (from 5 to 19 years) with recurrent fractures and found that the risk for bone fracture is twice higher when there is decrease of 1 SD in BMD.[16]

With regard to adolescent models, studies carried out in Brazil show that, in spite of being thin, these adolescents are considered healthy according to the following parameters: body composition, eating habits, and eating behavior.[4,5] Nevertheless, studies on health bone and its relation with body composition and important nutrients for the acquisition and maintenance of bone mass have not been conducted so far. Therefore, the objective of the present study was to assess the BMD and to relate it to the dietary intake and body composition of adolescent runway models and non-models.

Methods

Cross-sectional study involving adolescent runway models and non-models. Models were selected at modeling agencies involved in the Model Health project of the Adolescent Care and Support Center (Centro de Atendimento e Apoio ao Adolescente, CAAA) of Universidade Federal de São Paulo (UNIFESP), São Paulo, Brazil. This project is aimed at providing integral health care to adolescent models by means of nutritional, medical, speech therapeutic, and psychological care, as well as investigating this population considered to be a nutritional risk group. The health professionals working in this project have been assessing and following up Brazilian models for more than 10 years. The following inclusion criteria were used in the present study: age between 15 and 18 years; menarche occurring more than 2 years before inclusion; being a runway model; at least 6 months of working experience in São Paulo; living in an apartment owned by the modeling agency. Exclusion criteria were: presence of chronic disease, self-reported recent weight loss, or eating disorders.[17]

The participants included in the control group were selected at public and private schools located in São Paulo. These adolescents were paired with the models by age (considering a difference of up to 6 months) and body mass index (BMI), with the same range of BMI percentile for gender and age according to the National Center for Health Statistics/Centers for Disease Control and Prevention (NCHS/CDC), 2008.[18] Inclusion criteria for the control group were: occurrence of menarche longer than 2 years before the study and living with family. Exclusion criteria were similar to those described for the adolescent models. We decided to pair the individuals according to BMI, that is, adolescents of the control group who were thin, due to the effect of choosing a career as a model on dietary intake, body composition, and bone health.

We used convenience sampling to select the models due to relation between the CAAA-UNIFESP and the biggest modeling agencies of São Paulo (n = 5) and to the possibility of assessing the methods included in the protocol of the above mentioned project of the CAAA-UNIFESP. Sample size was calculated based on the mean number of adolescents living in each apartment (n = 10), number of apartments belonging to each agency (n = 1), and number of agencies included in this study (n = 5), totaling 50 models. However, after five visits to the apartments, we reached a total number of 41 models who met the inclusion criteria. Of these, two refused to participate in the study and six missed one of the appointments scheduled for physical examination. It is important to mention that the anamnesis initially administered to the adolescents who missed one of the appointments for data collection showed similar characteristics than those found for the rest of the group.

With the purpose of selecting adolescent non-models, we measured the weight and height of approximately 1,000 adolescents. At first, we selected 33 adolescents, and when there was a refusal to participate or one of them missed the appointment for physical examination, another adolescent was selected. Therefore, 66 adolescents comprised the final sample (33 models and 33 non-models).

The present study was approved by the Research Ethics Committee of UNIFESP under the protocol no. 0989/03.

For BMD assessment, we used the dual-energy X ray absorptiometry (DEXA) technique by means of the Lunar® DPX Alpha model, version 1.15, and the computer program Lunar DPX Alpha.

The assessment of the adolescents' bone mass was performed in the lumbar spine (L1 and L4) according to the recommendations of the International Society of Clinical Densitometry.[19] Z score was calculated considering individuals of the same sex and belonging to the same age group as recommended by the literature. Those values showing variations of up to -1 SD below the mean for the individuals' age were considered to be desirable bone density rates. Variations between -1 and -2 SD were considered to be within the threshold range (lower desirable limit); and those lower or equal to -2 SD were classified as BMD below the desirable value for the individuals' age.[15] The test was carried out by the same professional (physician) in all volunteers.

With the purpose of assessing body composition, we used air-displacement plethysmography in a Bod Pod® chamber, and the examination was performed at the Center of Studies in Psychobiology and Exercises (CEPE) of UNIFESP. The examination was carried out by a trained physical education teacher, who was responsible for all assessments.

The participants' weight was measured in kg using an electronic scale attached to Bod Pod®. Height was measured in centimeters using a vertical stadiometer Sanny®. Based on these data, BMI (kg/m^2) was calculated and its classification was determined according to the CDC curves.[18]

Identification data and information regarding physical activity were collected using a questionnaire. Dietary intake was assessed by means of a 3-day-food record completed on non-consecutive days, which enabled the collection of mean/median values of energy (kcal), calcium (mg), phosphorus (mg), vitamin D (μg), and vitamin K (mg). We used the computer program Nutrition Data System for Research[20] to carry out the calculations.

Food record was used as the instrument to assess dietary intake due to its high specificity to describe foods and preparation methods. In addition, it is widely used in the literature, since it includes 3 non-consecutive days, enabling the control of consumption variation. These characteristics make it a good method to assess dietary intake. One of its limitations is the underreporting of the dietary intake; however, it is worth noting that all participants were instructed to take daily notes of their dietary intake in home measures recording the information as reliably as possible. In addition, when the subjects returned the dietary record, the content was checked by a nutritionist with the purpose of clearing up doubts and providing detailed information on the foods consumed.

In order to estimate the total energy requirement (TER), we considered the metabolism rate at rest measured by indirect calorimetry carried out at CEPE/UNIFESP and the level of physical activity suggested by FAO (1985). Energy intake (EI) assessment was performed considering the mean values of TER ±20% as desirable.

The mean intake of calcium, vitamin K, and vitamin D was assessed considering the values recommended as adequate intake (AI). The assessment of other micronutrients (magnesium and phosphorus) was conducted taking into consideration the estimated average requirement (EAR).[21]

Statistical analysis of the data was performed using the following tests: Kolmogorov-Smirnov test, Student's *t* test or Mann-Whitney test, Pearson or Spearman's correlation test, chi-square test or Fisher's exact test. The variables with normal distribution are expressed as mean and standard deviation, whereas the other variables are expressed as median and confidence interval (95%). The computer program Statistical Package for the Social Sciences (SPSS), version 12.0, was used, and the significance level was set at $p < 0.05$.

With the purpose of verifying the association between the intake of nutrients and the other variables, we adjusted the nutrients according to the dietary energy using methods of nutrient density and residual nutrient.

Results

The study population included 66 female adolescents. Thirty-three of them were runway models (mean working experience = 1 year and 6 months) and 33 were non-models, aged from 15 to 18 years, and their mean age was 16.75±1.04 years.

We found that 24% of the adolescents had BMI lower than the ideal values for their age and approximately 60% of them were found to be between percentile 5 and 25 of the BMI curve.

Practice of physical activity was reported by 60.6% of the models and 63.6% of the non-models ($p = 0.80$), during longer periods of time by the models (5.0; 95%CI 3.9-4.9 hours vs. 2.0; 95%CI 2.0-3.8 hours among the non-models) ($p < 0.001$). Walking was the physical activity mentioned by the models, and the practice of physical activity at school was mentioned by the non-models.

Table 1 shows the anthropometric characteristics, body composition, and BMD of the groups studied.

Table 1 - Distribution of adolescents according to anthropometry, body composition, and bone mineral density

	Non-models (n = 33)				Models (n = 33)			
Variables	**Minimal**	**Maximum**	**Mean**	**SD**	**Minimal**	**Maximum**	**Mean**	**SD**
BMI (kg/m²)	16.27	20.54	17.80	1.05	15.64	21.03	18.10	1.19
Weight (kg)	37.70	57.30	47.72	5.05	45.80	66.20	55.72*	4.53
Height (cm)	150.00	174.00	163.52	6.24	170.00	183.00	175.33*	3.47
Lean body mass (kg)	30.20	44.50	37.22	3.84	35.80	48.20	42.53*	3.35
Fat (kg)	5.60	16.40	10.50	3.38	8.50	19.60	13.18*	2.25
BMD (L1-L4) (g/cm²)	0.945	1.315	1.096	0.102	0.931	1.258	1.108	0.080

BMD = bone mineral density; BMI = body mass index; SD = standard deviation.
* $p < 0.01$ according to Student's *t* test.

BMD values were similar between models and non-models (Table 1). When BMD was classified according to the standard deviation of the mean for age, we found that 6% of the adolescents of both groups had low BMD for their age ($p > 0.05$) (Table 2).

With regard to energy intake, we found a lower mean value among models (1,480.93±582.95 kcal vs. 1,973.00±557.63 kcal) than among non-models ($p < 0.05$) and high proportion of calorie consumption below recommended values (54.5% for models and 33.3% for non-models; $p > 0.05$).

Regarding micronutrients, we found that 97% of the adolescents of both groups had mean calcium intake lower than the recommended values. Similarly, 81.8% of the models and 97% of the non-models consumed lower amounts of vitamin D than the AI for this nutrient ($p > 0.05$). Insufficient consumption was also detected with regard to vitamin K, since 66.6% of the models and 57.6% of the non-models had mean intake of this vitamin lower than the recommended value for their age ($p > 0.05$).

In terms of magnesium intake, we found that 14.7% of the models and 25.8% of the non-models had appropriate intake ($p > 0.05$). On the other hand, with regard to phosphorus, we found a percentage of inappropriateness of 59.9% among the models and 48% among the non-models ($p > 0.05$). Table 3 shows the mean values of micronutrient intake.

Assessing the body compartments (fat and lean body mass), we found a significant correlation only between lean body mass (kg) and BMD in both groups (Figure 1). Among the non-models, we also found a positive correlation between BMD and weight ($r = 0.488$; $p = 0.004$) and between BMD and height ($r = 0.535$; $p = 0.001$). There was not association of BMD with minerals and vitamins in the crude or adjusted values for dietary energy or between BMD and physical activity.

Table 2 - Percentage distribution of adolescents according to the classification of bone mineral density

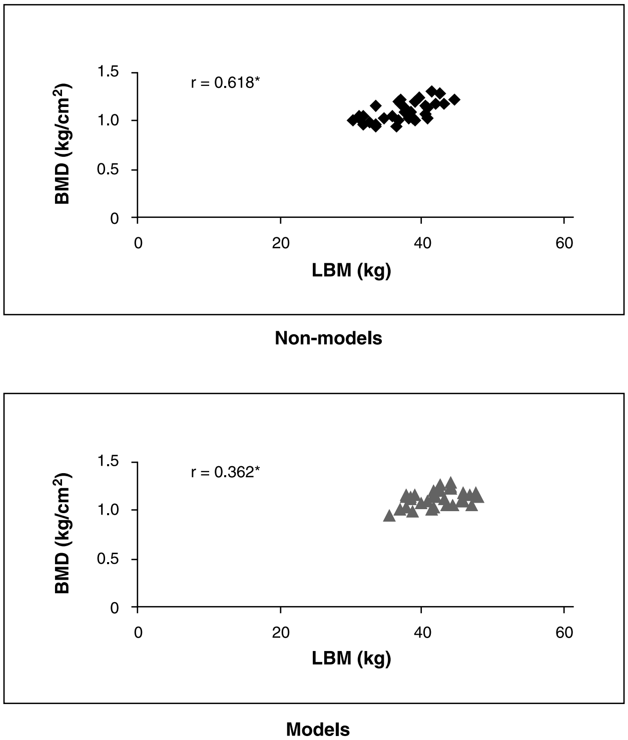
BMD	**Non-models (n = 33), n (%)**	**Models (n = 33), n (%)**
Low	2 (6.0)	2 (6.0)
Threshold	13 (39.4)	9 (27.3)
Normal	18 (54.5)	22 (67.0)

BMD = bone mineral density.
$p > 0.05$ according to Fisher's exact test or chi-square test.

Table 3 - Distribution of the groups according to the mean intake values of calcium, phosphorus, magnesium, vitamin K, and vitamin D

	Non-models (n = 33)				Models (n = 33)			
Variable	**Minimal**	**Maximum**	**Mean**	**SD**	**Minimal**	**Maximum**	**Mean**	**SD**
Calcium (mg)	14.12	1449.46	723.27	319.90	195.11	1605.61	744.20	325.78
Magnesium (mg)	94.61	444.84	243.91	84.20	62.75	423.38	211.74	84.37
Phosphorus (mg)	522.78	1834.77	1068.41	328.42	370.43	1934.32	969.93	361.73
Vitamin K (mg)	26.72	610.35	100.71	102.74	16.38	152.90	66.02	36.67
Vitamin D (µg)	0.42	5.66	2.68	1.51	0.70	10.44	3.54	2.57

SD = standard deviation.
$p < 0.05$ according to Student's *t* test.



BMD = bone mineral density; LBM = lean body mass.
* $p < 0.05$ according to Pearson's correlation.

Figure 1 - Correlation between bone mineral density (g/cm^2) and lean body mass (kg) of adolescent models and non-models

Discussion

In the present study, there were not differences between the BMD of models and non-models (1.108 vs. 1.096 g/cm^2), with lean body mass being the only body compartment related to BMD in both groups. Other studies have shown similar results relating BMD and body composition in adolescents,[22,23] demonstrating that this body compartment may be one of the main determinants of BMD in this phase of life.

In addition to the similarity of interrelation between BMD and lean body mass, we found that 6% of the adolescents taking part in the present study showed BMD below the desirable value. We also detected that 27.3% of the models and 39.4% of the non-models had threshold values of BMD ($p > 0.05$). These findings show that models, in spite of having a peculiar biotype related to their profession, have BMD values similar to those of non-models. Also, these results are a reason for concern because more than 30% of the adolescents of both groups have BMD values lower than the desirable values for this phase of life during which there is great acquisition of bone mass. Such findings deserve to be highlighted considering the importance of BMD in this period of life for the prevention of fractures and for future bone health; therefore, they should be further investigated by means of prospective studies.

It is also important to highlight the fact that the lower frequency of models, although without statistical significance, within the threshold classification of BMD can be related to higher levels of physical activity in this group due to the positive role played by exercises in bone health, even if this activity is not considered to have a great impact on the increase of bone mass.[24]

Studies conducted with adolescents from different continents and who had different nutritional statuses have shown results similar to those found in the present study in spite of the differences regarding the samples and the methods used. A Portuguese study assessing female adolescents found normal values in 84.9% of them, while the rest of the sample was at risk of osteopenia.[6] In Brazil, 83 overweight adolescents were compared with 89 eutrophic adolescents (according to BMI), and a higher BMD was found among overweight/obese adolescents, confirming the influence of body weight on bone mass.[7]

Another Brazilian study assessed 14 women from 15 to 34 years old with anorexia nervosa, median BMI of 15.7 kg/m^2 and median time of amenorrhea of 12.5 months and found that median BMD was 0.92 g/cm^2 and, when BMD values were categorized, the authors found that 64% of the sample had some degree of bone mass impairment.[25]

In contrast with the similarity regarding bone mass, there were significant differences in terms of dietary intake between models and non-models. We found that the first group had a significantly lower calorie intake and that among the participants there was high proportion of calorie intake below the values recommended, showing an unfavorable value to the bone mass considering that the low energy intake at this phase of life is one of the risk factors for osteoporosis.[2] It is important to emphasize that this low intake might be caused by real low consumption due to several reasons (little appetite, wish to lose weight, low food availability, among others), or by underreporting of dietary intake. It is important to point out, however, that other authors have found similar inappropriateness in studies with adolescents and that the presence of eating disorders was ruled out in the present study (data not shown).

In terms of micronutrients, we found inadequacy in both groups, with special emphasis to the low calcium intake (approximately 700 mg/day). Confirming these findings, a study assessing the dietary pattern o children and adolescents throughout years showed that the calcium intake is reduced in adolescence compared with childhood, causing insufficient calcium intake during an essential period for growth.[26] Similarly, studies conducted in Brazil have demonstrated low consumption of dairy products and, as a consequence, low calcium intake by adolescents.[27-29]

The mean intake of magnesium and phosphorus was also below the recommended values for age, as well as the intake of vitamin D and K. In the same way as calcium, these nutrients are important for the bone mineralization process taking place at this phase of life.[8,9]

The consumption of food rich in vitamins and minerals among models might be reduced due to the routine of the profession, with the common habit of skipping or replacing important meals due to tests, photo sessions and fashion shows that may last for most of the day. However, the inadequacy also detected among non-models reinforces the characteristics of the dietary intake found among adolescents by different authors.

The present study showed that lean body mass was the only body compartment that was related to BMD in both groups. In addition, our results pointed out important inadequate aspects of the dietary intake that may have a negative influence on the acquisition of bone mass, which is increased during this phase of life.

Conclusion

In our sample, in disagreement with other studies, there was not association between BMD and dietary intake and practice of physical exercise. In spite of that, there is consensus in the literature regarding the importance of a well-balanced diet and regular physical exercises for bone mass acquisition. The small size of our sample might have contributed to the lack of significant associations. Despite this limitation, it is worth highlighting that our data may contribute for future studies, as well as prompt studies aimed at clarifying the influence of professional modeling on the bone health of adolescents.

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