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Original article

Socioeconomic Status and Bone Mass in Spanish Adolescents. The HELENA Study

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A B S T R A C T

Purpose: Socioeconomic status (SES) has been frequently associated with body composition, particularly fat mass and obesity. However, the SES-bone mass association is not clear. We aimed to evaluate the associations between different SES indicators (Family Affluence Scale, parental education, and occupation) and bone mineral content in Spanish adolescents.
Methods: Participants were 322 adolescents (164 boys and 158 girls, 12.5–17.5 years) from the Healthy Lifestyle in Europe by Nutrition in Adolescence study. The social background of the adolescents was self-reported using an SES questionnaire, and the bone variables were measured using dual-energy x-ray absorptiometry. Physical activity was measured using accelerometers. Calcium intake was estimated from two nonconsecutive 24 hours recalls. One-way analysis of covariance was performed to examine the relationships between SES indicators and bone mass using different sets of confounders: basic model (sex + sexual maturation), model 1 (basic model + height), model 2 (basic model + lean mass), and model 3 (basic model + calcium intake + average physical activity).
Results: Adjusted results showed no association between SES indicators and whole-body or total hip bone mineral content. Additional analyses were performed in lumbar spine, pelvis, and hip subregions (femoral neck, trochanter, and intertrochanter), and no significant associations were observed at these sites either.
Conclusions: Our data do not support a link between different SES indicators (Family Affluence Scale, parental education, and occupation) and bone mass in adolescents.

Adolescence is a key period for bone development, and it has a large influence on adult skeletal health [1]. Although genetics greatly determines bone mass [2], environmental and lifestyle factors, such as physical activity (PA) [3,4] and nutrition (e.g., calcium intake) [5], have important osteogenic effects. SES is known to be a strong environmental factor related to both PA [6,7] and nutrition [8,9], as well as to different health outcomes. For instance, an association between SES and body composition,

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particularly fat mass and obesity, has been reported [10,11]. Because of its influence on PA and nutrition, it can be hypothesized that SES may play a role in the development of bone mass, yet this association is still poorly understood. Some studies have observed that the higher the SES, the higher the bone mass in children and adolescents [12–15], whereas others have observed the opposite [16] or no association [13,17,18]. Some of these studies have not taken into account relevant confounders, such as PA or lean mass, which make comparison and interpretation of the results difficult.

Although the methodology for assessing SES largely differs among studies, some SES indicators have been commonly used, such as parental education and occupation [12,13,15–17]. The Family Affluence Scale (FAS) is another SES indicator that refers to the family expenditure and consumption and has shown to have a good validity in young population [19,20].

The Healthy Lifestyle in Europe by Nutrition in Adolescence Cross-Sectional Study (HELENA-CSS) used harmonized and well-standardized methods of measurement in European adolescents in 2006–2007 [21]. The HELENA-CSS retrieved interesting information on SES and bone mineral content (BMC), and provides a good opportunity to explore the association between these variables in adolescence, after controlling for key confounders, such as lean mass, objectively measured PA, and calcium intake. In the present study, we aimed to evaluate the associations between different SES indicators (FAS, parental education, and occupation) and BMC in Spanish adolescents.

Methods

Subjects

The methods and procedures of the HELENA-CSS have been described in detail elsewhere [22]. In this report, we focus on the sample from Zaragoza, Spain, one of the 10 centers (cities) involved in the HELENA-CSS, where bone mass was measured by dual-energy x-ray absorptiometry (DXA). Inclusion criteria were to have valid data on DXA (bone and lean mass), height, objectively measured PA, calcium intake, sexual maturation, and SES indicators (FAS, parental education, and occupation). Sixty adolescents from Zaragoza were excluded because of a lack of information in any of these variables. A total of 164 boys and 158 girls were finally included in the analyses. The participants included ($n = 322$) in our analyses did not differ from those excluded from Zaragoza ($n = 60$) or from the rest of the HELENA-CSS sample ($n = 3{,}206$) in weight, height, body mass index (BMI), and the SES indicators studied. Parents and adolescents signed an informed consent, and the protocol was approved by the Ethics Committee of Clinical Research from the Government of Aragón (Ethics Committee of Clinical Research from the government of Aragón [CEICA]; Spain) [23].

Socioeconomic status

The FAS is based on the concept of material conditions in the family. Currie et al [20] chose a set of items that refer to family expenditure and consumption (affluence). The FAS is a valid SES index in young people and has been previously used in large epidemiologic studies (e.g., the Health Behaviour in School-aged Children [19]). The scale is composed of four questions: Do you have your own bedroom? (No = 0, Yes = 1); How many cars are there in your family? (None = 0, 1 = 1, 2 = 2, > 2 = 3); How many computers are there in your home? (None = 0, 1 = 1, 2 = 2, ≥ 3 = 3); Do you have Internet access at home? (No = 0, Yes = 1.) We computed a final score by summing the answers from all the questions (range, 0–8). Finally, we grouped these scores in three levels: low (0–2), medium (3–5), and high (6–8) [24].

Parental education and occupation were also included as measures of SES [12,13,15–17,25]. In the present study, parental education included four categories: lower education, lower secondary education, higher secondary education, and higher education or university degree. We considered these categories as low, low-medium, medium-high, and high educational levels, respectively. The question designed for parental occupation included 12 categories: legislators, senior officials or managers, professionals, technicians and associate professionals, clerks, service workers and shop and market sales workers, skilled agricultural and fishery worker, craft and related workers, plant and machine operators and assemblers, unskilled occupations, armed forces, other namely, and finally, does not work. In the present study, we grouped them into four categories to obtain larger and homogeneous sample size at each group: low, medium-high, high occupational level, and others. The category "other namely" was excluded from our analyses ($n = 32$) because of the wide variability of the answers and the low frequency accumulated for each answer.

Anthropometric measurements

Anthropometric data in the HELENA-CSS were obtained following International guidelines [26]. Body weight (kg) and height (cm) were measured with an electronic scale (Type SECA 861; SECA, Hamburg, Germany) and a stadiometer (Type SECA 225; SECA, Hamburg, Germany), respectively.

Pubertal status assessment

A physician examined the adolescents to classify them in one of the five stages proposed by Tanner and Whitehouse [27].

Calcium intake

Two nonconsecutive 24 hours recalls, using the HELENA-DIAT (Dietary Assessment Tool, HELENA Consortium) software [28], were performed to estimate the mean daily calcium intake of the adolescents. For the assessment of calcium intake, the food composition tables published by Farrán et al [29] were used for the Spanish adolescents.

Physical activity

PA was assessed using a uniaxial accelerometer (Actigraph GT1M, Manufacturing Technology, Inc, Pensacola, FL). The time sampling interval (epoch) was set at 15 seconds. A minimum of 8 hours of registration/day during at least 3 days were selected as an inclusion criterion. Average PA (counts/min) was calculated as previously described [30].

Bone, lean, and fat mass

Osseous and soft tissues of the adolescents were measured with DXA, using a pediatric version of the software QDR-Explorer (Hologic Corp., Software version 12.4, Bedford, MA). A lumbar spine phantom was used to calibrate DXA equipment as recom-

Table 1
Descriptive characteristics of the studied adolescents (n = 322)

Variable	All (n = 322)	Boys (n = 164)	Girls (n = 158)	*p*
Age (year)	14.8 ± 1.2	14.8 ± 1.3	14.8 ± 1.1	.968
Sexual maturation (I/II/III/IV/V) (%)	(0/2/7/14/77)	(0/3/9/21/67)	(0/1/4/6/89)	**< .001**
Body mass (kg)	58.2 ± 12.9	61.8 ± 14.9	54.6 ± 9.1	**< .001**
Height (cm)	164.7 ± 10.9	168.7 ± 22.1	160.5 ± 7.3	**< .001**
BMI (kg/m^2)	21.2 ± 3.2	21.2 ± 3.3	21.1 ± 3.2	.931
Lean mass (kg)	40.5 ± 8.4	45.4 ± 8.3	35.5 ± 4.6	**< .001**
BMC (g)	1994.17 ± 414.95	2112.16 ± 461.71	1871.69 ± 317.93	**< .001**
Calcium intake (mg/d)	760.11 ± 350.8	850.6 ± 391.0	666.1 ± 274.6	**< .001**
Average PA (counts/min)	421.87 ± 147.94	472.81 ± 156.82	369.01 ± 117.03	**< .001**
FAS (low/med/high) (%)	(7/72/21)	(7/71/22)	(8/73/19)	.572
Father education (low/low-med/med-high/high) (%)	(14/31/23/32)	(12/32/25/31)	(16/30/22/32)	.687
Mother education (low/low-med/med-high/high) (%)	(16/24/29/31)	(15/23/35/27)	(17/25/22/36)	.912
Father occupation (low/med-high/high) (%)	(39/39/22)	(34/47/19)	(43/32/25)	.683
Mother occupation (low/med-high/high) (%)	(39/40/21)	(41/38/21)	(37/43/20)	.692

Sex differences in **bold letters (*p* < . 001).**
BMI = body mass index; BMC = bone mineral content; PA = physical activity, FAS = Family Affluence Scale.

mended by the manufacturer. Whole-body, subtotal body (whole body minus head), total hip, and lumbar spine measurements were obtained. For the whole-body measurement, adolescents were scanned in supine position, and the scans were performed at high resolution [31]. The bone mineral density (bone mineral density [BMD] g·cm^{-2}), area (cm^2), fat mass (g), and lean mass (g) [body mass – (fat mass + bone mass)] were determined for each individual from total and regional analysis of the whole-body scan. BMC (g) was calculated using the formula BMC = BMD·area. Two additional examinations were conducted to estimate bone mass at the lumbar spine (mean, L1–L4) and hip subregions (trochanter, intertrochanter, and femoral neck) as previously described [32].

The coefficients of variation of the DXA were calculated for regional analysis of the complete body scan in 49 adolescents with repositioning. The coefficients of variation were 2.3% for BMC; 1.3% for BMD; 2.6% for bone area; and 1.9% for lean mass [33].

Statistics

All the residuals showed a satisfactory pattern (normal distribution). Data are presented as means and standard deviations, unless otherwise stated. Spearman rank correlation coefficients (Spearman's rho) were calculated among body composition, sexual maturation, height, calcium intake, the average PA, and SES indicators. To analyze the association between SES indicators and bone mass, one-way analysis of covariance was performed. The categorized variables of SES were entered as fix factor, bone mass–related variables were entered as dependent variables, and sex and sexual maturation (basic model) were included as covariates. Additional models were also examined: model 1 (basic model + height), model 2 (basic model + lean mass), and model 3 (basic model + calcium intake + average PA).

All the analyses were performed using the Statistical Package for Social Sciences software (SPSS, vs. 15.0 for WINDOWS; SPSS, Inc., Chicago, IL), and values of $p<.05$ were considered statistically significant.

Results

Table 1 shows descriptive characteristics of the study sample. Differences were observed between boys and girls in sexual maturation, body mass, height, lean mass, BMC, calcium intake, and the average PA (all $p < .001$); however, no sex differences were found in any of the SES indicators (all $p > .5$).

Table 2
Spearman's rank correlation coefficients among body composition, sexual maturation, height, calcium intake, physical activity, and socioeconomic status indicators (n = 322)

	Whole body BMC	Total hip BMC	Sexual maturation	Height	Lean mass	Calcium intake	Average PA	FAS	Mother education	Father education	Mother occupation	Father occupation
Whole body BMC	1.00	.77*	.44*	.73*	.79*	.12**	.14**	−.14	−.02	−.03	−.04	.07
Total hip BMC	—	1.00	.17**	.73*	.83*	.23*	.29*	−.02	−.02	−.03	−.04	−.01
Sexual maturation	—	—	1.00	.28*	.26*	−.11	−.13**	−.11	−.14*	−.07	−.06	−.07
Height	—	—	—	1.00	.80*	.20*	.18*	.02	.09	.08	.03	.08
Lean mass	—	—	—	—	1.00	.16*	.24*	−.01	−.01	.03	−.01	−.01
Calcium intake	—	—	—	—	—	1.00	.22*	.05	−.02	−.02	.06	.05
Average PA	—	—	—	—	—	—	1.00	−.02	−.01	.01	.02	−.01
FAS	—	—	—	—	—	—	—	1.00	.13**	.26*	.25*	.25*
Mother education	—	—	—	—	—	—	—	—	1.00	.54*	.53*	.38*
Father education	—	—	—	—	—	—	—	—	—	1.00	.36*	.48*
Mother occupation	—	—	—	—	—	—	—	—	—	—	1.00	.43*
Father occupation	—	—	—	—	—	—	—	—	—	—	—	1.00

BMC = bone mineral content; FAS = Family Affluence Scale; PA = physical activity.
* $p<.001$.
** $p<.01$.

Table 3
Bone mass differences according to FAS in adolescents (n = 322)

FAS	Basic model[a] Mean ± SE	Model 1[b] Mean ± SE	Model 2[c] Mean ± SE	Model 3[d] Mean ± SE
Whole body				
Low	1986.31 ± 68.59	2000.06 ± 60.33	1992.06 ± 41.63	1981.56 ± 67.08
Medium	1978.79 ± 22.07	1982.47 ± 19.41	1984.97 ± 13.40	1980.08 ± 21.61
High	2051.08 ± 41.48	2033.12 ± 36.52	2027.27 ± 25.19	2048.27 ± 40.74
Total hip				
Low	33.37 ± 1.55	33.61 ± 1.45	33.46 ± 1.26	33.26 ± 1.51
Medium	31.49 ± .49	31.56 ± .47	31.59 ± .41	31.51 ± .49
High	31.45 ± .94	31.15 ± .88	31.06 ± .76	31.43 ± .92

SE = standard error.
No significant differences were found ($p > .05$).
[a] Adjusted by confounders (sex and sexual maturation).
[b] Adjusted by confounders + height.
[c] Adjusted by confounders + lean mass.
[d] Adjusted by confounders + calcium intake + average physical activity.

Positive correlations (Table 2) were found among whole-body and total hip BMC and sexual maturation (.17 < r < .44, $p < .01$), height (r = .73, $p < .001$), lean mass (.79 < r < .83, $p < .001$), calcium intake (.12 < r < .23, $p < .01$), and average PA (.14 < r < .29, $p < .01$). In addition, positive correlations were found among SES indicators (.13 < r < .54, $p < .01$). Tables 3–5 show the associations among SES indicators and bone mass–related variables (whole-body and total hip BMC). No associations were observed among SES indicators and whole body (all $p > .3$) or total hip (all $p > .1$) BMC, after adjustment for relevant confounders (i.e., sex, sexual maturation, height, lean mass, calcium intake, and average PA). Similarly, associations were not found after considering the individual items that composed the FAS variable (data not shown). However, grouping low and medium levels of FAS, we found significant borderline differences in femoral neck BMC (p = .049) in model 3 (data not shown). Additional analyses were performed in subtotal body, lumbar spine, pelvis, and hip subregions (femoral neck, trochanter, and intertrochanter), and no association was observed at these sites either (all $p > .05$; data not shown).

Discussion

The findings of the present study indicate that SES, as assessed by FAS, parental education, and occupation, is not related with BMC in adolescents. Confounders, such as lean mass, calcium, and PA, do not seem to have an important role in the SES-bone mass association.

Table 4
Bone mass differences according to parental education in adolescents (n = 322)

Educational level	Basic model[a] Mean ± SE	Model 1[b] Mean ± SE	Model 2[c] Mean ± SE	Model 3[d] Mean ± SE
Whole body				
Mother education				
Low	1979.14 ± 47.69	2029.59 ± 42.26	2002.91 ± 29.04	1967.52 ± 46.81
Low-med	1957.64 ± 38.31	1982.93 ± 33.79	1976.56 ± 23.32	1972.26 ± 37.73
Med-high	1997.14 ± 35.31	1990.93 ± 31.06	2007.09 ± 21.49	1993.19 ± 34.61
High	2033.61 ± 33.66	1995.01 ± 29.87	1998.36 ± 20.54	2031.81 ± 32.94
Father education				
Low	1997.58 ± 50.28	2044.06 ± 44.32	2032.82 ± 30.46	1995.63 ± 49.17
Low-med	1981. 37 ± 33.71	1990.86 ± 29.55	1985.06 ± 20.39	1978.89 ± 33.02
Med-high	1993.74 ± 38.92	1988.28 ± 34.11	1984.26 ± 23.55	2004.71 ± 38.21
High	2005.52 ± 33.38	1979.73 ± 29.37	1993.33 ± 20.21	2000.74 ± 32.64
Total hip				
Mother education				
Low	32.88 ± 1.07	33.74 ± 1.01	33.27 ± .88	32.57 ± 1.05
Low-med	30.39 ± .86	30.82 ± .81	30.71 ± .71	30.76 ± .85
Med-high	31.28 ± .79	31.18 ± .74	31.45 ± .65	31.16 ± .78
High	32.47 ± .76	31.81 ± .71	31.89 ± .62	32.44 ± .74
Father education				
Low	32.35 ± 1.13	33.15 ± 1.06	32.93 ± .92	32.33 ± 1.11
Low-med	31.85 ± .76	32.01 ± .71	31.91 ± .62	31.76 ± .74
Med-high	31.17 ± .88	31.08 ± .82	31.01 ± .71	31.46 ± .86
High	31.42 ± .75	30.98 ± .71	31.22 ± .61	31.31 ± .73

SE = standard error.
No significant differences were found ($p > .05$).
[a] Adjusted by confounders (sex and sexual maturation).
[b] Adjusted by confounders + height.
[c] Adjusted by confounders + lean mass.
[d] Adjusted by confounders + calcium intake + average physical activity.

Table 5
Bone mass differences according to parental occupation in adolescents (n = 322)

Educational level	Basic model[a] Mean ± SE	Model 1[b] Mean ± SE	Model 2[c] Mean ± SE	Model 3[d] Mean ± SE
Whole body				
Mother occupation				
Low	1966.48 ± 35.09	1998.37 ± 27.74	1981.84 ± 22.27	1975.98 ± 34.18
Medium	1994.05 ± 34.33	1953.21 ± 27.23	1976.04 ± 21.79	1992.44 ± 33.38
High	1969.62 ± 35.09	1989.81 ± 27.75	1976.11 ± 30.39	1954.97 ± 46.57
Father occupation				
Low	1969.99 ± 32.05	2000.28 ± 28.44	1973.86 ± 19.27	1978.61 ± 31.38
Medium	1995.74 ± 32.01	1983.19 ± 28.24	2006.69 ± 19.25	1990.17 ± 31.23
High	2036.66 ± 42.97	2005.05 ± 38.03	2009.92 ± 25.87	2031.27 ± 41.87
Total hip				
Mother occupation				
Low	31.35 ± .69	31.91 ± .59	31.61 ± .53	31.49 ± .67
Medium	31.34 ± .68	30.61 ± .57	31.04 ± .52	31.36 ± .66
High	30.82 ± .95	31.17 ± .79	30.92 ± .73	30.49 ± .92
Father occupation				
Low	31.27 ± .69	31.81 ± .65	31.37 ± .55	31.39 ± .68
Medium	31.11 ± .69	30.89 ± .64	31.29 ± .55	31.03 ± .68
High	32.07 ± .93	31.51 ± .86	31.62 ± .74	31.99 ± .91

SE = standard error. No significant differences were found ($p > .05$).
[a] Adjusted by confounders (sex and sexual maturation).
[b] Adjusted by confounders + height.
[c] Adjusted by confounders + lean mass.
[d] Adjusted by confounders + calcium intake + average physical activity.

Positive correlations were found among bone-related variables and sexual maturation, height, lean mass, calcium intake, and average PA, and therefore, were included as confounders, as we did in previous studies [30]. The confounders were entered into the models in consecutive steps to explore their role in the associations. The *basic model* included sex and sexual maturation [34], and no association was found. The additional inclusion of height (*model 1*) as a covariate is essential when using DXA because it is not a 3-D device, and there might be overestimation of bone mass in taller adolescents. Body composition, especially lean mass (*model 2*), has been shown to be a strong predictor of bone mass in adolescents [30]. Finally, there are other factors related with lifestyles that have been shown to be associated with bone mass and also with SES, such as objectively measured PA [32] and nutrition, especially calcium intake (*model 3*) [5]. The inclusion of the previous confounders did not alter the results, supporting the lack of association between SES and bone. In addition, it is well known that vigorous PA has been associated with bone mass [4]. Further analyses were performed using the vigorous PA as a confounder instead of the average PA and results remained unchanged (data not shown). Because the acquisition of bone mass is site-specific [34], it might be that the possible effect of SES on bone mass could be reflected in other regions. Secondary analyses performed in regions of clinical relevance to osteoporosis (lumbar spine and femoral neck) and also in other skeletal regions (subtotal body, pelvis, trochanter, and intertrochanter) confirmed the lack of association between SES and bone.

Some environmental factors, such as PA and nutrition (i.e., calcium intake), are associated with SES in adolescents [35]. It has been shown that adolescents with higher SES (assessed through father education) were more likely to engage in extracurricular sports than those with lower SES [10], and they have been shown to have higher fitness levels [24], which is also positively associated with bone mass [33]. In addition, they could have better nutritional habits, including calcium consumption, and therefore, to have higher levels of bone mass. The data from the present study suggest that the differences in SES, assessed by FAS, parental education, and occupation, are not enough to induce changes on bone mass in Spanish adolescents, after controlling for relevant confounders (i.e., PA, calcium intake, and lean mass). This could be due to the strong influence of genetics on bone mass. Further studies analyzing the effect of SES on bone, considering genetics and other environmental and lifestyles factors, are still needed.

Our results agree with several studies performed with children and adolescents. Lantz et al [13] showed that SES (father's educational level) had no significant effect on whole-body BMC and BMD, after adjusting for total energy expenditure, PA, weight, height, and gender in a sample of 15-year Swedish adolescents. Norris et al [15] showed that SES (caregiver education) had no significant effect on either femoral neck or lumbar spine BMC, after adjusting for body size, pubertal development, PA, habitual dietary calcium intake, and body composition (lean and/or fat mass) in poor urban South African children. Also in agreement with our findings, Clark et al [17] showed that SES (maternal education) was not associated with fracture risk at the age of 9–11 year, and Lyons et al [18] showed that there was no association between deprivation (low SES) and fracture risk in children.

By contrast, literature shows discrepant results. Some studies reported positive associations among SES and bone-related variables (i.e., bone age, whole-body BMC and BMD, and distal forearm and calcaneus BMD) in children and adolescents, after taking into account the role of confounders, such as age, sexual maturation, height, and weight [12–15]. In addition, Arabi et al [36] showed that boys and girls of higher SES tended to have higher BMD than those from a lower SES at the subtotal body (whole body minus head), lumbar spine, forearm, total hip, femoral neck, and trochanter sites. On the contrary, the study of Clark et al [16] showed a negative relationship between SES (maternal education, maternal occupation, and social class) and subtotal BMC and BMD in children, after adjusting for age, gender, and height.

Several factors could explain these differences, such as geographical factors, as well as social and cultural contexts of each country.

Limitations and strengths

Although we controlled for several potential confounders, we cannot be certain that other unmeasured confounders, such as genetic variation or dietary intake (i.e., protein intake), have not influenced our observations. The different methodology used to assess SES in different studies is a problematic issue. Our study focused on adolescents from Zaragoza, Spain, as bone mass by DXA was only assessed in this subsample of the HELENA-CSS, so the conclusions cannot be generalized to whatever population. Nevertheless, the lack of differences concerning weight, height, BMI, and SES indicators between the study sample and the whole HELENA-CSS sample indicates that the study sample is representative of the European adolescents participating in the HELENA study. Cross-sectional studies only can provide suggestive evidence concerning causal relationships. However, in this specific case, it seems reasonable to think that SES could influence BMC, whereas the mechanisms by which bone mass could determine higher or lower SES are not so clear.

The use of sophisticated methods, such as DXA, to assess body composition, and the use of accelerometers to assess PA are strengths of the study. This study includes a rather complete set of confounders, that is, sex, sexual maturation, height, lean mass, calcium intake, and average PA, which is crucial to examine the current research question.

Conclusions

Our data do not support a link between SES (assessed through FAS, parental education, and parental occupation) and bone mass in adolescents.

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References

[1] Rizzoli R, Bianchi ML, Garabédian M, et al. Maximizing bone mineral mass gain during growth for the prevention of fractures in the adolescents and the elderly. Bone 2010;46:294–305.
[2] Cheng S, Völgyi E, Tylavsky FA, et al. Trait-specific tracking and determinants of body composition: A 7-year follow-up study of pubertal growth in girls. BMC Med 2009;7:5.
[3] Branca F, Valtueña S. Calcium, physical activity and bone health–Building bones for a stronger future. Public Health Nutr 2001;4:117–23.
[4] Gracia-Marco L, Moreno LA, Ortega FB, et al. Levels of physical activity that predict optimal bone mass in adolescents the HELENA study. Am J Prev Med 2011;40:599–607.
[5] Vicente-Rodríguez G, Ezquerra J, Mesana MI, et al. Independent and combined effect of nutrition and exercise on bone mass development. J Bone Miner Metab 2008;26:416–24.
[6] Seiluri T, Lahti J, Rahkonen O, et al. Changes in occupational class differences in leisure-time physical activity: A follow-up study. Int J Behav Nutr Phys Act 2011;8:14.
[7] Boone-Heinonen J, Diez Roux AV, Kiefe CI, et al. Neighborhood socioeconomic status predictors of physical activity through young to middle adulthood: The CARDIA study. Soc Sci Med 2011;72:641–9.
[8] McCabe-Sellers BJ, Bowman S, Stuff JE, et al. Assessment of the diet quality of US adults in the Lower Mississippi Delta. Am J Clin Nutr 2007;86:697–706.
[9] Popkin BM, Zizza C, Siega-Riz AM. Who is leading the change? U.S. dietary quality comparison between 1965 and 1996. Am J Prev Med 2003;25:1–8.
[10] Gracia-Marco L, Tomas C, Vicente-Rodriguez G, et al. Extra-curricular participation in sports and socio-demographic factors in Spanish adolescents: The AVENA study. J Sports Sci 2010;28:1383–9.
[11] Jiménez-Pavón D, Ortega FB, Ruiz JR, et al. Influence of socioeconomic factors on fitness and fatness in Spanish adolescents: The AVENA study. Int J Pediatr Obes 2010;5:467–73.
[12] Chaumoitre K, Lamtali S, Baali A, et al. Influence of socioeconomic status and body mass index on bone age. Horm Res Paediatr 2010;74:129–35.
[13] Lantz H, Bratteby LE, Fors H, et al. Body composition in a cohort of Swedish adolescents aged 15, 17 and 20.5 years. Acta Paediatr 2008;97:1691–7.
[14] Marwaha RK, Tandon N, Reddy DH, et al. Peripheral bone mineral density and its predictors in healthy school girls from two different socioeconomic groups in Delhi. Osteoporos Int 2007;18:375–83.
[15] Norris SA, Sheppard ZA, Griffiths PL, et al. Current socio-economic measures, and not those measured during infancy, affect bone mass in poor urban South African children. J Bone Miner Res 2008;23:1409–16.
[16] Clark EM, Ness A, Tobias JH. Social position affects bone mass in childhood through opposing actions on height and weight. J Bone Miner Res 2005;20:2082–9.
[17] Clark EM, Ness AR, Tobias JH. Vigorous physical activity increases fracture risk in children irrespective of bone mass: A prospective study of the independent risk factors for fractures in healthy children. J Bone Miner Res 2008;23:1012–22.
[18] Lyons RA, Delahunty AM, Heaven M, et al. Incidence of childhood fractures in affluent and deprived areas: Population based study. BMJ 2000;320:149.
[19] Currie C, Molcho M, Boyce W, et al. Researching health inequalities in adolescents: The development of the Health Behaviour in School-aged Children (HBSC) Family Affluence Scale. Soc Sci Med 2008;66:1429–36.
[20] Currie CE, Elton RA, Todd J, Platt S. Indicators of socioeconomic status for adolescents: The WHO Health Behaviour in School-aged Children Survey. Health Educ Res 1997;12:385–97.
[21] Moreno LA, González-Gross M, Kersting M, et al. Assessing, understanding and modifying nutritional status, eating habits and physical activity in European adolescents: The HELENA (Healthy Lifestyle in Europe by Nutrition in Adolescence) Study. Public Health Nutr 2008;11:288–99.
[22] Moreno LA, De Henauw S, Gonzalez-Gross M, et al. Design and implementation of the healthy lifestyle in Europe by nutrition in adolescence cross-sectional study. Int J Obes (Lond) 2008;32(Suppl 5):S4–11.
[23] Beghin L, Castera M, Manios Y, et al. Quality assurance of ethical issues and regulatory aspects relating to good clinical practices in the HELENA cross-sectional study. Int J Obes (Lond) 2008;32(Suppl 5):S12–8.
[24] Jiménez Pavón D, Ortega FP, Ruiz JR, et al. Socioeconomic status influences physical fitness in European adolescents independently of body fat and physical activity: The HELENA study. Nutr Hosp 2010;25:311–6.
[25] Rey-Lopez JP, Tomas C, Vicente-Rodriguez G, et al. Sedentary behaviours and socio-economic status in Spanish adolescents: The AVENA study. Eur J Public Health 2011;21:151–7.
[26] Nagy E, Vicente-Rodriguez G, Manios Y, et al. Harmonization process and reliability assessment of anthropometric measurements in a multicenter study in adolescents. Int J Obes (Lond) 2008;32(Suppl 5):S58–65.
[27] Tanner JM, Whitehouse RH. Clinical longitudinal standards for height, weight, height velocity, weight velocity, and stages of puberty. Arch Dis Child 1976;51:170–9.
[28] Vereecken CA, Covents M, Sichert-Hellert W, et al. Development and evaluation of a self-administered computerized 24-h dietary recall method for adolescents in Europe. Int J Obes (Lond) 2008;32(Suppl 5):S26–34.
[29] Farrán A, Zamora R, Cervera P, de Composición de Alimentos del Centre T, d'Ensenyament. Superior de Nutrició i Dietètica (CESNID). Barcelona, 2004.
[30] Gracia-Marco L, Ortega FB, Jimenez Pavon D, et al. Adiposity and bone health in Spanish adolescents. The HELENA study. Osteoporos Int (in press).
[31] Vicente-Rodriguez G, Jimenez-Ramirez J, Ara I, et al. Enhanced bone mass and physical fitness in prepubescent footballers. Bone 2003;33:853–9.
[32] Vicente-Rodriguez G, Ara I, Perez-Gomez J, et al. Muscular development and physical activity as major determinants of femoral bone mass acquisition during growth. Br J Sports Med 2005;39:611–6.

[33] Gracia-Marco L, Vicente-Rodriguez G, Casajus JA, et al. Effect of fitness and physical activity on bone mass in adolescents: The HELENA Study. Eur J Appl Physiol (in press).
[34] Gracia-Marco L, Vicente-Rodríguez G, Valtueña J, et al. Bone mass and bone metabolism markers during adolescence: The HELENA Study. Horm Res Paediatr 2010;74:339–50.
[35] Gökçe-Kutsal Y, Atalay A, Sonel-Tur B. Effect of socio-economic status on bone density in children: Comparison of two schools by quantitative ultrasound measurement. J Pediatr Endocrinol Metab 2007;20:53–8.
[36] Arabi A, Nabulsi M, Maalouf J, et al. Bone mineral density by age, gender, pubertal stages, and socioeconomic status in healthy Lebanese children and adolescents. Bone 2004;35:1169–79.