JCN Journal of Clinical Nursing

Journal of Clinical Nursing

RESEARCH IN BRIEF

# Low bone mineral density in a cohort of normal, overweight and obese Chilean adolescents

Estela Blanco, Marcela Reyes, Raquel A Burrows, Suzanna M Martinez and Sheila Gahagan

**Accepted for publication:** 26 June 2011

## Aim

This study aimed to report on a high prevalence of low bone mineral density (BMD) and to explore the relationship between BMD, sex and body composition among a cohort of Chilean adolescents.

## Background

Osteoporosis, associated with low BMD, is a public health problem. Peak bone mass (PBM) is influenced by genetics, nutrition, body weight and physical activity, with 90% of PBM obtained by age 18 years. Recent research challenges the belief that obesity protects against low BMD. In a study of overweight and obese adults, researchers noted that overweight status was neutral or protective of BMD, whereas obesity was associated with lower bone mass (Greco *et al.* 2010).

Relationships between adiposity, bone health and fracture risk in children and adolescents remain under debate. One study reports overweight/obese children have insufficient bone health relative to body weight and may be at increased risk of bone fractures (Goulding *et al.* 2000). Studies in older adolescents are needed, as bone mass in this period may best predict future bone health.

## Methods

Subjects were part of a larger cohort ($n$ = 1645) studied since infancy as part of an iron deficiency anemia preventive trial and follow-up study in Santiago, Chile (Lozoff *et al.* 2003). They were recruited at 16–17 years old to participate in a study of obesity and cardiovascular risk. We report on the first 308 adolescents studied in this wave of data collection. Parents signed informed consent, and adolescents signed informed assent. Ethics Boards at the Institute of Nutrition and Food Technology, University of Chile, University of California, San Diego and the University of Michigan approved this study.

Anthropometry and bone health were measured at a single time point between 16–17 years. Weight and height were assessed in duplicate with a Precision Hispana scale and a stadiometer accurate to 0·1 kg and 0·1 cm, respectively. Participants were measured without shoes, wearing underwear, in the Frankfurt position. We determined body mass index (BMI) percentile using World Health Organization growth standards. Whole-body BMD was assessed using Lunar Prodigy dual-energy X-ray absorptiometry scan. All participants were measured according to standard protocols on the same machine calibrated every other day. BMD $z$-scores are based on National Health and Nutrition Examination Survey III and adjusted for age. We categorised BMD $z$-score

**Authors:** *Estela Blanco*, MPH, MA, Research Associate, University of California, San Diego, La Jolla, CA, USA; *Marcela Reyes*, MD, PhD, Assistant Professor, Institute of Nutrition and Food Technology (INTA), University of Chile; *Raquel A Burrows*, MD, Associate Professor, Institute of Nutrition and Food Technology (INTA), University of Chile, Santiago, Chile; *Suzanna M Martinez*, PhD, MS, Post-Doctoral Fellow, University of California; *Sheila Gahagan*, MD, MPH, Professor, University of California, San Diego, La Jolla, CA and Center for Human Growth and Development, University of Michigan, Ann Arbor, MI, USA

**Correspondence:** Sheila Gahagan, Professor, University of California, San Diego, 9500 Gilman Drive #0927, La Jolla, CA 92093-0927, USA. Telephone: +1 619 243 2422.

**E-mail:** sgahagan@ucsd.edu

 
doi: 10.1111/j.1365-2702.2011.03959.x

as normal ($z$-score $> -1$) and low ($s$-score $\leq -1$). We evaluated nutrition and physical activity with self-report measures validated in Chilean children (available on request).

Statistical analyses were performed using SPSS (version 18.0; SPSS, Chicago, IL, USA). Bivariate associations were determined with Pearson's correlation coefficients. Using linear regression, we evaluated the relationship between BMD $z$-score, gender, physical activity and nutrition. We estimated the odds of having low BMD status, considering gender and BMI status with logistic regression.

## Results

Participants were 16·8 (SD 0·3) years old, 49% girls, with an average BMI percentile of 65. Three per cent were underweight and 38% were overweight or obese (BMI ≥85th percentile). Twenty-one per cent of the adolescents met the criteria for low BMD. Girls were more likely to have low BMD than boys, 31 and 10%, respectively ($p < 0{\cdot}01$). Gender differences in all weight groups were maintained; the normal weight group showed the greatest gender disparity, with 40% of girls and 13% of boys with low BMD ($p < 0{\cdot}01$) (Table 1). Overall, BMD $z$-score positively correlated with BMI percentile ($r = 0{\cdot}51$, $p < 0{\cdot}001$), per cent fat mass ($r = 0{\cdot}16$, $p < 0{\cdot}01$) and waist circumference ($r = 0{\cdot}51$, $p < 0{\cdot}001$) and negatively associated with per cent lean mass ($r = -0{\cdot}17$, $p < 0{\cdot}01$). In multiple linear regression, higher BMD $z$-score positively associated with higher BMI percentile ($p < 0{\cdot}001$). Physical activity and nutrition were not related to higher BMD $z$-score.

Compared with overweight and obese adolescents, the odds of low BMD were four times greater in normal weight participants (95% CI 1·9–8·2, $p < 0{\cdot}01$) and 4·6 times greater in girls, compared with boys (95% CI 2·4–9·1, $p < 0{\cdot}01$). Nonetheless, 13% of the overweight participants met criteria for low BMD. Two obese participants (5% of obese participants) met the criteria for low BMD.

**Table 1** Comparing bone density by gender and BMI status

| | Male *n* (%) | Female *n* (%) |
|---|---|---|
| Normal weight ($n$ = 129) | | |
| Normal bone density | 83 (87%) | 52 (60%) |
| Low bone density | 12 (13%) | 35 (40%)* |
| Overweight ($n$ = 38) | | |
| Normal bone density | 26 (93%) | 25 (81%) |
| Low bone density | 2 (7%) | 6 (19%) |
| Obese ($n$ = 40) | | |
| Normal bone density | 28 (100%) | 28 (90%) |
| Low bone density | 0 (0%) | 3 (10%) |

BMI, body mass index.
*Chi-square test significant at $p < 0{\cdot}01$.

## Conclusions

In our sample of low- to middle-income Chilean adolescents, low BMD was prevalent without sparing overweight or obese participants. Notably, girls had higher proportions of low density compared with boys. We highlight this disparity as girls are at higher risk of developing osteoporosis in adulthood.

This disparity may differ by context. In Chile, a substantial decrease in the nutritional quality of foods consumed among school-age children has been documented in the last decade – with insufficient amounts of dairy, fruits and vegetables and high amounts of energy dense foods and sugar-sweetened beverages (Olivares *et al.* 2007). A disparity by socioeconomic status (SES) has also been noted, with Chilean children of medium–high SES consuming more dairy and less energy dense foods compared with children of low SES (Olivares *et al.* 2007).

Our study furthers the discussion regarding adiposity and BMD in adolescents. Bone mineral content and area have been proposed as the preferred measures of bone mass in growing youth (i.e. pre- and peri-pubertal) (Pollock *et al.* 2010). We used BMD as our measure of bone health, considering that, given participants' age, most would be in Tanner stage 4 or 5. We found higher BMI was generally associated with normal BMD, with notable exceptions. We studied older adolescents, when PBM has been nearly reached and when it may be most predictive of future fracture risk.

This study is not without limitations, most notably the cross-sectional design. Recent work illustrates the necessity for longitudinal studies related to changes in bone health and weight loss (Goulding *et al.* 2000). Longitudinal studies during adolescence may help to determine whether bone alterations track into adulthood. Strengths of this study include a community-based sample with a relatively large number of adolescents in all weight categories. Future research should explore how age of onset of adiposity and fat distribution influence the relationship between low BMD and fracture risk. Weight-bearing physical activity, calcium intake, Vitamin D levels and how these factors interact with adiposity as related to BMD should also be assessed.

## Relevance to clinical practice

Fat mass is protective of adult bone health; however, this relationship remains unclear in children and adolescents.

  

Nursing care professionals should be aware that female adolescents may be at particular risk of poor bone health and overweight and obese adolescents may not be immune.

## Key words

adolescent body composition, bone development, DXA, future health risks, nurses, nursing

## Acknowledgements

We would like to express our gratitude to the participants and their families for their ongoing participation. The project described was supported by Award Number R01HL088530 (PI: Gahagan) from the National Heart, Lung, And Blood Institute. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Heart, Lung, And Blood Institute or the National Institutes of Health.

## Contributions

Study design: EB, MR, RB, SG; data collection: MR, RB; data analysis: EB, SM and manuscript preparation: EB, MR, SM, SG.

## Conflict of interest

None to disclose.

## References

Goulding A, Taylor RW, Jones IE, McAuley KA, Manning PJ & Williams SM (2000) Overweight and obese children have low bone mass and area for their weight. *International Journal of Obesity* **24**, 627–632.

Greco EA, Fornari R, Rossi F, Santiemma V, Prossomariti G, Annoscia C, Aversa A, Brama M, Marini M, Donini LM, Spera G, Lenzi A, Lubrano C & Migliaccio S (2010) Is obesity protection for osteoporosis? Evaluation of bone mineral density in individuals with high body mass index *International Journal of Clinical Practice* **64**, 817–820.

Lozoff B, De Andraca I, Castillo M, Smith JB, Walter T & Pino P (2003) Behavioral and developmental effects of preventing iron-deficiency anemia in healthy full-term infants. *Pediatrics* **112**, 846–854.

Olivares CS, Bustos ZN, Lera ML & Zelada ME (2007) [Nutritional status, food consumption and physical activity in female school children of different socioeconomic levels from Santiago, Chile]. *Revista Medica de Chile* **135**, 71–78.

Pollock NK, Bernard PJ, Wenger K, Misra S, Gower BA, Allison JD, Zhu H & Davis CL (2010) Lower bone mass in prepubertal overweight children with prediabetes. *Journal of Bone and Mineral Research* **25**, 2484–2493.