"Bounce at the Bell": a novel program of short bouts of exercise improves proximal femur bone mass in early pubertal children


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Objectives: To examine the effects of a simple and inexpensive physical activity intervention on change in bone mass and structure in school aged children.

Methods: Fifty one children (n = 23 boys and 28 girls; mean age 10.1 years) participated in “Bounce at the Bell” which consisted of 10 counter-movement jumps 3 x per day (total ~3 min/day). Controls were 71 matched children who followed usual school practice. We assessed dietary calcium, physical activity, bone mineral content (BMC) and bone area at the lumbar spine, total body, and proximal femur. Proximal femur scans were also analysed for bone geometry and structural strength using the hip structural analysis program. Lean and fat mass (g) were also calculated.

Results: Groups were similar at baseline and did not differ in weight, height, total body, lumbar spine, proximal femur, or femoral neck BMC. Control children had a greater increase in adjusted total body BMC (1.4%). Intervention children gained significantly more BMC at the total proximal femur (2%) and the intertrochanteric region (27%). Change in bone structural parameters did not differ between groups.

Conclusions: This novel, easily implemented exercise program, took only a few minutes each day and enhanced bone mass at the weight bearing proximal femur in early pubertal children. A large, randomised study of boys and girls should be undertaken powered to test the effectiveness of Bounce at the Bell in children at different stages of maturity, and in boys and girls independently.

Although our previous interventions were implemented within the school curriculum, they involved some equipment (stools, jump ropes, etc) and needed 10–20 min 3 x/week during the school day. Other interventions in children required 20–90 min after school and/or specially trained teachers. For a school based program that targets the growing skeleton to gain acceptance on a population-wide basis, it must be effective, simple to administer, possible to perform in the classroom, hallway, or schoolyard, short in duration, and inexpensive. Promising data from young animals indicated that short, discrete bouts of exercise administered with rest inserted between loading bouts, were more effective than a single longer bout of exercise for improving bone mass and strength. These experimental data showed that mechanosensitivity of bone declined quickly after initiation of a loading bout and that only a few bouts of loading per session were required to optimise the osteogenic response. To our knowledge, no such intervention has yet been assessed in children.

Based on this advance in understanding of bone biology in animals, we conducted an 8 month controlled trial of a very simple, inexpensive, and easily to implement intervention comprised of short bouts of activity (‘Bounce at the Bell’) interspersed throughout the school day. The intervention required only ~3 min/day to complete and was implemented according to

Abbreviations: aBMD, areal bone mineral density; ANCOVA, analysis of covariance; ANOVA, analysis of variance; BMD, bone mineral density; BW, body weight; CSA, cross-sectional area; CSMI, cross-sectional moment of inertia; DXA, dual energy x ray absorptiometry; FFQ, food frequency questionnaire; FN, femoral neck; FS, femoral shaft; GT, greater trochanter; HSA, hip structural analysis; IT, intertrochanter; LS, lumbar spine; NIN, narrow neck; PAQ-C, Physical Activity Questionnaire for Children; PF, proximal femur; UBC, the University of British Columbia
with no equipment, by generalist teachers, and within the classroom. Our objective was to examine the effects of this intervention on change in bone mass and geometry in grade 4 and 5 children, and to compare outcomes to our previous Healthy Bones intervention trials.

METHODS

Data collection procedures were the same as described in our previous reports and are summarised below. All measurements took place in the University of British Columbia (UBC) Bone Health Research Laboratory in Vancouver, and the Bounce at the Bell exercise program (detailed below) was conducted within intervention schools.

Design and participants

Bounce at the Bell was a prospective cohort study. We recruited three schools in the Richmond School District to undertake the 8 month (1 school year) intervention. Participants were measured at baseline (start of the school year, September) and after 8 months (end of the school year, June). Fifty one children in grade 4 or 5 intervention classrooms consented to participate and were measured at the UBC Bone Health Research laboratory. All 51 children in the intervention group returned for follow up measurement at the end of the school year.

Our control group was comprised of children matched for race, sex, height, and maturity who attended Healthy Bones II control schools, also in the Richmond School District. The Healthy Bones II trial was completed 1 year prior to the current study and evaluated the effect of a 20 month, intervention carried out in the elementary school classroom. Our objective was to examine the effects of this intervention on change in bone mass and geometry in grade 4 and 5 children, and to compare outcomes to our previous Healthy Bones intervention trials.

Bounce at the Bell intervention

Bounce at the Bell was simple to administer and perform, short in duration (requiring approximately 3 min/day), and inexpensive. The program was carried out in the elementary school classroom with no equipment and required only minimal training of generalist (rather than physical education) teachers.

We provided teachers in intervention schools with an instruction booklet that illustrated counter-movement jumps. The research assistant met the teachers three times throughout the year to observe, demonstrate, and review the jumps. Teachers instructed the children to perform 10 counter movement jumps (two foot take off, clutch knees, two foot landing), three times each school day (once at morning bell, once at noon bell, and once at home time bell). Ground reaction forces for a counter movement jump were five times body weight (BW) and maximum rate of force was >400 BWs in an independent sample of 70 boys and girls measured in the UBC Biomechanics Laboratory. Teachers maintained a record of student attendance and the average number of jumps the class performed each day. Records were collected at the school visits. Both intervention and control schools partook of physical education as mandated by their school board (2×40 min classes per week, on average).

Measurements

Health history

Parent(s) completed a health history questionnaire for their child and all healthy children from whom we obtained parental consent were eligible to participate. None of the children in the study were taking medications or had any disease known to influence bone metabolism.

Descriptive variables

Maturity was rated (1–5) against Tanner breast (girls) and pubic hair (boys) line drawings. Children were either assisted by a member of the research team with each follow up assessment, or completed a maturity assessment with written instructions (in English or Chinese) under parental supervision at home. We used the mean of two measures of stretch stature for sitting and standing height (mm) and BW (kg). Sitting height was subtracted from standing height to estimate leg length (mm). We report the mean of two calf girth (cm) measures, assessed at the site of maximal girth using a metal tape measure. We assessed vertical jump (to the nearest mm) to represent dynamic power.

Questionnaires, as per our previous trials, were administered three times during the school year (autumn, winter, spring) to assess dietary intake of calcium and participation in physical activity outside the intervention. We used the average of these three values for analyses. The calcium food frequency questionnaire (FFQ) has been validated in Asian and Caucasian children. A bilingual (Chinese-English) trained measurer assisted non-English speaking Chinese children. Physical activity during the previous 7 days was determined by a modified version of the Physical Activity Questionnaire for Children (PAQ-C).

General physical activity scores were calculated as an average of the PAQ-C items, in a continuous range between 1 (low activity) and 5 (high activity) and as estimated minutes per week. We modified the PAQ-C to include an estimate of time spent in loaded physical activity and the number of nights of extracurricular sports activities per week.

Bone mineral content and bone area

We used a Hologic QDR 4500 W bone densitometer (DXA) to assess bone mass and area. BMC (g) and bone area (BA, cm²) were measured for total body, lumbar spine (LS), and proximal femur (PF). Proximal femur scans were analysed for the femoral neck (FN), and greater trochanteric (GT) and intertrochanteric (IT) subregions. Two trained and qualified technicians acquired all scans. Scans were analysed using standardised procedures by one researcher (LM). Total body lean mass and fat mass (g) were obtained from total body DXA scans. Our precision values and quality assurance procedures for densitometry are reported elsewhere.

Hipp structural analysis

We applied the hip structural analysis (HSA) program to proximal femur DXA scans to evaluate bone geometry and estimate structural strength at the narrow neck (NN) and femoral shaft (FS) regions of the proximal femur. The HSA program locates the axes of the femoral neck and shaft from the bone mineral image and then derives structural geometry from profiles of pixel value along lines orthogonal to the bone axis at specific points. Profiles of bone mass from each region are used to derive aBMD (g/cm²) directly as the average value. Bone cross-sectional area (CSA) is derived as the integral of the profile of pixel values converted to centimetres and subperiosteal width is the blur corrected width of the profile. Cross-sectional moment of inertia (CSMI) is derived as the integral of pixel area times the square of distance from the profile centroid. The section modulus (Z), a determinant of bending strength, is computed as $Z = \frac{CSMI}{(maximum}$. 

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distance from centre of mass to outer cortical margin). Like BMC, CSA measures the amount of bone within the cross-section but expresses the quantity in terms of cortical equivalent surface area rather than mineral mass.

The fan beam mode of the QDR 4500 produces an error in pixel spacing along the fan beam direction that varies with the height of the bone above the scanner table surface. A special calibration phantom was used to quantify the height effect with a pair of identical copper foils at different (known) distances above the tabletop. This yielded a correction for pixel spacing as a function of the height of the bone. Based on computerised tomography observations, the proximal femur is located at approximately the mid-sagittal plane at the level of the hip. Bone height was estimated for each scan as one half of the average soft tissue thickness derived from attenuation data in the hip region.

**Statistical analyses**

We used analysis of variance (ANOVA) to compare baseline bone, anthropometry, dietary calcium, performance, and physical activity variables between intervention and control groups. To compare change in BA, BMC, and bone structure between groups, we used a 2 (sex)×2 (group) analysis of covariance (ANCOVA, SPSS GLM procedure). We also used ANOVA (sex by group) to compare 8 month change in anthropometry, dietary calcium, performance, and physical activity variables. We report absolute change (final—baseline) (table 1), adjusted change (table 2), and adjusted per cent change [1{(final—baseline)/baseline}×100] (text) for bone mass and structure variables. As in previous studies, we controlled for baseline bone value and weight, change in bone mass and structure variables. As in previous studies, we controlled for baseline bone value and weight, change in height, and final maturity stage to account for the well known variability in growth and change in growth parameters for children of a similar chronological age. We also controlled for physical activity load time to account for group differences at baseline (p=0.076). Data were analysed with SPSS version 11.0 and significance was set at p<0.05.

**RESULTS**

**Compliance**

Compliance ranged from 10 jumps three times per day, 2 days per week, to 10 jumps three times per day 5 days per week with a mean uptake of 90±34 jumps per week. Average school attendance of the intervention children was 96.8% ranging from 0 to 25 days absent (excluding statutory and school holidays).

**Table 1 Baseline and change (where relevant) in descriptive characteristics for intervention and control groups**

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>8 month change</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
<td>Intervention</td>
</tr>
<tr>
<td></td>
<td>n=73</td>
<td>n=51</td>
</tr>
<tr>
<td>Age, years</td>
<td>10.2±0.43</td>
<td>10.1±0.5</td>
</tr>
<tr>
<td>Height, cm</td>
<td>140.4±6.0</td>
<td>139.8±7.0</td>
</tr>
<tr>
<td>Sitting height, cm</td>
<td>74.2±3.5</td>
<td>73.9±3.8</td>
</tr>
<tr>
<td>Leg length, cm</td>
<td>65.9±3.3</td>
<td>65.8±3.6</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>35.1±8.0</td>
<td>35.7±9.1</td>
</tr>
<tr>
<td>Fat mass, kg</td>
<td>8.9±5.0</td>
<td>8.9±4.9</td>
</tr>
<tr>
<td>Lean mass, kg</td>
<td>26.1±4.0</td>
<td>25.3±4.6</td>
</tr>
<tr>
<td>Calf girth, cm</td>
<td>29.0±2.8</td>
<td>28.8±3.2</td>
</tr>
<tr>
<td>Vertical jump</td>
<td>23.6±6.1</td>
<td>23.1±6.1</td>
</tr>
<tr>
<td>Calcium, mg/day†</td>
<td>832±380</td>
<td>821±377</td>
</tr>
<tr>
<td>Physical activity score†</td>
<td>3.0±0.5</td>
<td>3.0±0.6</td>
</tr>
<tr>
<td>Physical activity load time,†</td>
<td>5.6±4.3</td>
<td>7.2±5.9</td>
</tr>
</tbody>
</table>

†Values were averaged from questionnaires administered three times over the year (autumn, winter, and spring).

*Significantly different from control group (p<0.01). p values refer to change between intervention and control over the study period.

Values are mean±SD.

**Bone mineral content and bone area**

Baseline (table 1) and 8 month change (table 2) in BMC and BA by DXA are presented. There were no differences between intervention and control groups at baseline for any bone variables. Control children demonstrated a significantly greater increase in total body BA (7.5±6.3%, p=0.004) and total body BMC (10.1±8.7%, p=0.036) over the study period (table 2). However, the intervention group gained significantly more BMC at the loaded total proximal femur (14.4±12.3%, p=0.019) (table 2, fig 1). This group difference was accounted for by a significantly greater increase in intertrochanteric BMC in the intervention group compared with controls (14.4±11.7%, p=0.017). Adjusted BA at the total proximal femur (+1.3%, p=0.072) and intertrochanteric region (+2.0%, p=0.065) also increased more (NS) in intervention children.

**Sex difference in response**

There were no significant sex group interactions for change in bone variables. There was, however, a trend for the bone response to be greater in boys at all regions of the proximal femur with the exception of the femoral neck. Intervention boys increased BMC by 3.1, 4.0, and 4.2% more than controls at the PF, IT, and GT regions, respectively. In contrast, girls in

Descriptive characteristics

Fifty one children participated in the intervention (n=23 boys and 28 girls). Control children who met the matching criteria for sex, height, and maturity were 36 boys and 39 girls, thus 24 children had a 2:1 match. Age ranged from 8.9 to 10.8 years at baseline for the intervention group and from 9.2 to 11.0 years for the control group. Control and intervention children matched on maturity were Tanner 1 (65%), 2 (33%), or 3 (2%) at baseline. At follow up, 36% of control and 25% of intervention children were Tanner stage 1, 53 and 56% were Tanner stage 2, and 11 and 15% were Tanner stage 3. One intervention boy reported advancing from Tanner stage 1 to Tanner stage 4.

There were 38% Caucasian, 48% Asian, and 15% other (including mixed ethnic, Black, and South Asian) children in both the control and intervention groups. Baseline values and 8 month change for anthropometry, performance variables, dietary calcium, and physical activity are presented (table 1). There were no significant differences between intervention and control groups at baseline or for change with the exception of a significantly greater increase in calf girth in the intervention children (1.9±3.8%, p=0.002).

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Sex difference in response

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the intervention group gained 1.0 and 1.4% more BMC than controls at the PF and IT regions, and demonstrated equivalent gains at the GT region. For both boys and girls, there was no difference in change between groups at the FN region. Control boys gained 3% more bone than intervention boys at the spine, while there was no difference for the girls (sex×group, p = 0.059).

**Hip structural analysis**

Although there were no significant differences between intervention and control groups for change in bone structural variables, the mean difference between groups favoured the intervention group at the femoral neck (table 3). At the narrow neck region, the intervention group had greater gains (NS) in bone section modulus (+3.3%) because of increased bone CSA (+2%) and cortical thickness (+1.2%) with no difference in subperisteal changes. Although the mean difference between groups favoured the control group at the femoral shaft, these non-significant differences for change were all less than 1.0%.

**DISCUSSION**

A novel intervention

Over the past decade a number of well designed experimental trials demonstrated that jumping-type exercises during childhood enhanced bone accrual. Although the concept that bone adapts to a dynamic mechanical environment is well established, the minimum effective dose that elicits such a response is not clear. In previous studies, weight bearing exercise programs were implemented either after school for 30–35 min, 3×/week (total: 90 min/week) or during elementary school physical education for 10–15 min, 3×/week (45 min/week). Given the increasing demands on elementary school teachers, and dwindling resources, it is unlikely that these bone health programs would be a feasible addition to an expanding academic curriculum.

Robling et al and Umemura’s animal experiments provide the rationale for Bounce at the Bell, a classroom intervention that required a commitment of only a few minutes per day, no additional resources, and minimal training. The present study demonstrated that this novel, simple, and inexpensive program of exercise enhanced bone health during childhood. In addition, Bounce at the Bell was effectively implemented by generalist teachers (not physical education specialists) in the elementary school classroom. Thus, this program could easily be adopted in elementary schools and has the potential to promote childhood bone health on a population-wide basis.

**Effectiveness of Bounce of the Bell for augmenting bone mass**

The magnitude of BMC changes in the present study were either greater than or equivalent to the reported gains over 8–10 months in studies that examined either girls or boys at a similar maturational stage (Tanner stages 1–3 at baseline). As in previous studies, the skeletal response to the Bounce at the Bell intervention was region and site specific. We previously reported significantly greater gains (~2%) for LS and FN BMC after 8 months of exercise in early pubertal girls and for the LS BMC and proximal femur BMD in pre and early pubertal boys. We have also reported greater gains for trochanteric aBMD in a combined group of younger (8.9 years) prepubertal boys and girls following a more moderate intervention. Our current findings also agreed with a similar site specific response in Finnish premenarcheal, but not postmenarcheal, girls.

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**Table 2** Baseline and adjusted 8 month change in BMC and area for control (n = 73) and intervention (n = 51) groups

<table>
<thead>
<tr>
<th></th>
<th>Baseline, mean (SD)</th>
<th>8 month change, mean (95% CI)</th>
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<tbody>
<tr>
<td></td>
<td>Control</td>
<td>Intervention</td>
</tr>
<tr>
<td>Total body</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMC, g</td>
<td>1047±169</td>
<td>1054±97</td>
</tr>
<tr>
<td>Area, cm²</td>
<td>1228±153</td>
<td>1232±178</td>
</tr>
<tr>
<td>Lumbar spine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMC, g</td>
<td>24.3±4.4</td>
<td>24.6±5.1</td>
</tr>
<tr>
<td>Area, cm²</td>
<td>38.5±4.4</td>
<td>39.2±4.5</td>
</tr>
<tr>
<td>Proximal femur</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMC, g</td>
<td>15.6±3.2</td>
<td>16.2±3.4</td>
</tr>
<tr>
<td>Area, cm²</td>
<td>22.7±2.6</td>
<td>23.3±3.0†</td>
</tr>
<tr>
<td>Femoral neck</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMC, g</td>
<td>10.2±2.2</td>
<td>10.6±2.2</td>
</tr>
<tr>
<td>Area, cm²</td>
<td>13.6±1.6</td>
<td>13.95±1.90</td>
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<tr>
<td>Greater trochanter</td>
<td></td>
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<tr>
<td>BMC, g</td>
<td>2.7±0.8</td>
<td>2.9±0.9</td>
</tr>
<tr>
<td>Area, cm²</td>
<td>5.1±1.1</td>
<td>5.3±1.2</td>
</tr>
<tr>
<td>Femoral neck</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMC, g</td>
<td>2.6±0.4</td>
<td>2.7±0.4</td>
</tr>
<tr>
<td>Area, cm²</td>
<td>4.0±0.3</td>
<td>4.0±0.4</td>
</tr>
</tbody>
</table>

All change values are adjusted for baseline bone, baseline weight, final Tanner stage, change in height, and physical activity load time. Significant group main effect by ANCOVA: *p<0.02; **p<0.05; †p<0.10.

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**Figure 1** Adjusted %change in proximal femur (PF) BMC for boys and girls in the intervention and control groups. Boys in the intervention group increased PF BMC 3% more than control boys, on average, compared with a 1% greater increase for intervention girls versus control girls. Group p<0.05.
Traditional exercise interventions in girls and boys of comparable age and at different stages of maturity. Our results support undertaking a randomised controlled trial of boys and girls powered to test the effectiveness of Bounce at the Bell on bone mass and structure in children of different races and ages and at different stages of maturity.

ACKNOWLEDGEMENTS

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Competing interests: none declared

Table 3 Baseline and adjusted 8 month change in hip structural analysis (HSA) variables for control (n = 73) and intervention (n = 51) groups

<table>
<thead>
<tr>
<th></th>
<th>Baseline, mean ± SD</th>
<th>8 month change*, mean (95% CI)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
<td>Intervention</td>
</tr>
<tr>
<td>Narrow neck</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMD, g/cm²</td>
<td>0.52 ± 0.06</td>
<td>0.010 (0.004–0.017)</td>
</tr>
<tr>
<td>Bone CSA, cm²</td>
<td>1.20 ± 0.19</td>
<td>0.055 (0.036–0.074)</td>
</tr>
<tr>
<td>Subperiosteal width, cm</td>
<td>2.42 ± 0.18</td>
<td>0.065 (0.048–0.082)</td>
</tr>
<tr>
<td>Section modulus, cm²</td>
<td>0.46 ± 0.10</td>
<td>0.030 (0.023–0.041)</td>
</tr>
<tr>
<td>Endosteal diameter, cm</td>
<td>2.23 ± 0.17</td>
<td>0.061 (0.044–0.077)</td>
</tr>
<tr>
<td>Cortical thickness, cm</td>
<td>0.099 ± 0.01</td>
<td>0.002 (0.001–0.003)</td>
</tr>
<tr>
<td>Femoral shaft</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMD, g/cm²</td>
<td>0.62 ± 0.08</td>
<td>0.029 (0.019–0.039)</td>
</tr>
<tr>
<td>Bone CSA, cm²</td>
<td>1.29 ± 0.20</td>
<td>0.018 (0.005–0.041)</td>
</tr>
<tr>
<td>Subperiosteal width, cm</td>
<td>2.18 ± 0.16</td>
<td>0.093 (0.076–0.111)</td>
</tr>
<tr>
<td>Section modulus, cm²</td>
<td>0.53 ± 0.11</td>
<td>0.068 (0.055–0.080)</td>
</tr>
<tr>
<td>Endosteal diameter, cm</td>
<td>1.76 ± 0.16</td>
<td>0.073 (0.053–0.093)</td>
</tr>
<tr>
<td>Cortical thickness, cm</td>
<td>0.21 ± 0.03</td>
<td>0.010 (0.006–0.014)</td>
</tr>
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</table>

†All change values are adjusted for baseline bone structure, baseline weight, final Tanner stage, change in height, and physical activity load time.

All non-significant (p >0.10).

Bounce of the Bell and bone structure

It is important to evaluate structural mechanisms that underpin changes in bone mass by DXA and this study adds valuable data in that regard. The percentage changes between intervention and control groups favoured the intervention group at the narrow neck site by 2% in CSA and 3.3% in section modulus. However, due to the relatively small sample size we may have been underpowered to demonstrate the significance of this effect. That said, the clinical relevance of these findings should not be overlooked given that HSA has been shown to be a better predictor of femoral breaking strength than bone mineral density. These percentage changes are consistent with the significant changes we reported from our 8 and 20 month trials with more traditional exercise interventions in girls and boys of similar maturity.

Strengths and limitations of the study

The key strengths of this study were: (i) the innovative intervention, (ii) the real world classroom setting and program delivery by generalist teachers, and (iii) the evaluation of dependent and independent variables known to be important based on our previous studies. Further, although not a randomised trial, our matched study design aimed to limit known biases in studies of children by ensuring groups were homogeneous for age, sex, race, and maturity. Finally, we evaluated bone structure so as to discern the mechanisms that may underpin bone changes by DXA.

The limitations of the study include the relatively small sample size, thus, we may have had insufficient power to demonstrate an effect of the intervention on bone structure. That said, we were adequately powered to demonstrate an effect of the intervention on BMC, which was our primary outcome variable. Despite matching, intervention children were engaged in marginally (NS) more loaded physical activity at baseline than control children. Although this 2 min per week more loaded activity is unlikely to affect the outcomes of this study, we controlled for this difference within our analysis. Although DXA derived HSA values provide an important estimate of bone structure, assessing a three-dimensional structure using two-dimensional imaging techniques is challenging. This is especially true in the growing skeleton. The estimates of cortical thickness and endosteal diameter employ assumptions of cross-sectional shape and relative distribution of trabecular and cortical bone within the femoral neck and intertrochanteric cross-sections. These assumptions have not been assessed in children.

SUMMARY

We have shown that an exercise program that can be easily implemented by elementary school teachers in only a few minutes each day enhances bone mass at the weight bearing proximal femur in participating children. Our results support undertaking a randomised controlled trial of boys and girls powered to test the effectiveness of Bounce at the Bell on bone mass and structure in children of different races and ages and at different stages of maturity.

What is already known on this topic

Most adult bone mass is acquired by the end of adolescence and appropriate mechanical loading can modify the mass, geometry, and structural strength of the skeleton during the growing years; the precise timing of exercise to augment bone parameters appears to be important.

What this study adds

A novel, easily implemented exercise program (Bounce at the Bell) took only a few minutes each day and enhanced bone mass at the weight bearing proximal femur in early pubertal children.
REFERENCES


