A Randomized Controlled Trial for the Primary Prevention of Osteoporosis Among Preadolescent Girl Scouts: 1-Year Outcomes of a Behavioral Program

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Objective To provide 1-year outcomes for a randomized controlled trial of a behavioral–educational intervention for the primary prevention of osteoporosis among 247 preadolescent girls.

Methods Girl Scout troops were randomly assigned to one of two intervention groups—a group comprising girls only (n = 73) and girls with their mothers (n = 94)—and a healthy-lifestyles control group (n = 80). Multilevel (hierarchical) models were employed to account for clustering of girls within troops.

Results Among girls who met the recommended levels of Ca at baseline, those in the intervention were significantly more likely to maintain or improve their intake at follow-up compared to controls. No significant group differences were found for changes in WBPA.

Conclusions A behavioral intervention for the primary prevention of osteoporosis holds promise for maintaining adequate Ca intake among preadolescent females.

Key words RCT; osteoporosis; primary prevention; behavioral intervention; dietary calcium intake; weight-bearing physical activity; multilevel modeling.

A research and clinical commitment to the primary prevention of illness is vitally important for the field of pediatric psychology, although little published research has documented successful intervention efforts in this area (Roberts, 1992; Roberts & Brown, 2000). To address this need, a randomized controlled trial (RCT) of a comprehensive behavioral intervention for the prevention of osteoporosis was developed.

Prevention of osteoporosis provides an opportunity in which to test behavioral interventions for improving healthy lifestyle behaviors among children. Osteoporosis is an important public health issue, affecting over 25 million people in the United States. More than 1.5 million fractures occur annually, costing the country's health system an estimated $10 billion due to increased disability, decreased quality of life, and premature death (French, Fulkerson, & Story, 2000). Peak bone mass is one of the major predictors of the risk of fracture in osteoporosis, and approximately 40% of the skeletal structure is built and enlarged during late childhood and early adolescence (Cummings, Kelsey, Nevitt, & O'Dowd, 1985; National Institute of Child Health and Development, 1999). The importance of attaining a high-peak bone mass is not restricted to preventing osteoporosis, because low bone-mineral density is also associated with fractures in childhood (Goulding et al., 1998). Females
are particularly at risk for the later development of osteoporosis and generally lack healthy lifestyle behaviors that promote accrual of bone mass.

The risk of developing osteoporosis can be reduced by the adoption of healthy lifestyle behaviors during late childhood and early adolescence (Teegarden, Lyle, Prouz, Johnston, & Weaver, 1999; Valimaki et al., 1994). Evidence demonstrates that increasing dietary calcium (Ca) intake and weight-bearing physical activity (WBPA) increase bone mass in children. In the past decade, the majority of WBPA and Ca supplement intervention studies have shown positive effects on bone-mass gains in children and in adolescents (for a review, see French et al., 2000).

A need exists for primary prevention interventions for preadolescent females based on their current lifestyle habits. Dietary Ca intake in many adolescent females is far below the recommended daily allowance (RDA), which is 1300 mg for children ages 6 to 19 years (National Institute of Child Health and Development, 1999). Estimates are that as many as 85% of adolescent females do not meet the RDA of Ca, with an average range of approximately 700 to 950 mg per day, and that more than half consume less than 500 mg per day (Eck & Hackett-Renner, 1992; Fleming & Heimbach, 1994; Miller, Kimes, Hui, Andon, & Johnston, 1991; Weaver, 1994).

Preadolescent and adolescent females also participate less frequently in physical activity than do males of the same age (Center for Disease Control and Prevention, 1998; McKenzie et al., 1995). While the recommended amount of WBPA for the prevention of osteoporosis has not yet been specified, adults are encouraged to engage in physical activity for 20 to 30 min per day, a recommendation based on the Surgeon General’s report on physical activity and health (U.S. Department of Health and Human Services, 1996). Studies documenting the frequency of WBPA in children could not be located; however, only 24% of females ages 12 to 21 years have reported engaging in regular physical activity (U.S. Department of Health and Human Services, 1996). This percentage would be expected to be even lower for WBPA, which excludes several physical activities popular among children, such as swimming, in-line skating, and bicycle riding.

Although many dietary interventions exist for the prevention of cardiovascular disease or the treatment of obesity, limited instances of such programs exist for the prevention of osteoporosis. A nutrition education program demonstrated significant increases in knowledge about Ca between the experimental (n = 29) and control (n = 20) groups, but no significant differences were reported in Ca intake at posttest or at 1-month follow-up (Green, McIntosh, & Wilson, 1991). To our knowledge, only one study has been published thus far that examined a behavioral intervention with intake of dietary Ca as a measured outcome. Its primary focus was on increasing caloric intake for children with cystic fibrosis (CF), although the consumption of diary products was recommended as being nutrient-rich sources of energy (Stark, Mackner, Kessler, Opipari, & Quittner, 2002). This study reported significant gains in dietary Ca intake with maintenance at 1-year follow-up. Because CF is a unique chronic condition, these results are not directly applicable to preventive behavioral interventions for physically healthy children.

We developed a targeted multicomponent behavioral–educational intervention based on the theory of social cognition and on successful elements identified from previous research (Bandura, 1986; Baranowski, 1997; Taylor, Baranowski, & Sallis, 1994). Our causal model postulates that psychosocial determinants of behavior interact to influence health behaviors, which—with genetic and hormonal factors—affect physiologic factors that affect disease risk. The hypothesized psychosocial determinants of child–parent health behaviors include behavioral factors such as self-monitoring, environmental factors such as peer and parental modeling, and individual factors such as knowledge about osteoporosis.

We tested the applicability of this model by implementing our intervention with Girl Scouts and their mothers in the troop setting. Our study design included testing the effectiveness of two versions of this intervention—one for girls only and the other for girls with their mothers—against a healthy-lifestyles control group. Our decision to compare two versions of this intervention was based on previous research demonstrating the benefits of parental support for improving children’s dietary habits (Epstein, Wing, Koeske, & Valoski, 1987; Fitzgibbon, Stolley, Avellone, Sugarman, & Chavez, 1996). We chose to include only females owing to their heightened risk for the development of osteoporosis (Teegarden et al., 1999). The narrow age range (8–11 years) was deliberate because the greatest percentage of bone mass is attained between ages 11 and 14 (Matkovic & Ilich, 1993; Nordin, 1997). Our intent was to intervene at the time just before the greatest bone mass gains. Our sample was primarily Caucasian, as African Americans have greater Ca retention, greater bone mass, and lower risk of fracture than Caucasians do (Bryant et al., 2003).

To our knowledge, the intervention’s focus on eating behavior and physical activity is novel because previous
intervention studies for increasing bone density among children for the primary prevention of osteoporosis have emphasized either Ca intake or WBPA, but not both.

We hypothesized that girls in the intervention groups would demonstrate significantly greater increases in their dietary Ca intake and in their WBPA levels between baseline and 1-year assessments relative to controls. We also examined whether this hypothesis would be supported when considering only girls who were not meeting recommended levels of Ca intake or WBPA at baseline. In addition, we hypothesized that girls in the intervention group with their mothers would have greater increases in their Ca intake and WBPA from baseline to the 1-year follow-up relative to participants in the girls-only intervention group. We examined whether this hypothesis would be supported when considering only girls who were not meeting the recommended levels at baseline. Our hypotheses for better outcomes in the intervention group with mothers were based on prior research (as mentioned) and on our baseline findings of significant associations between family social support and higher Ca intake (Ievers-Landis et al., 2003).

Method

Participants

Participants were 247 preadolescent girls who completed the baseline and 1-year follow-up assessments for an RCT of a behavioral intervention designed to prevent the later development of osteoporosis. This RCT was approved by the investigators' institutional review board. Preadolescent girls between the ages of 8 and 11 years who had not yet undergone menarche were recruited for participation from the Girl Scouts Council. To avoid potential confounding factors that might affect the outcomes for the intervention groups, girls who had certain medical conditions or were taking medications that could be associated with low bone mass were excluded. The exclusionary criteria—based on the past or present condition of the girls—were as follows: a history of cancer; the presence of severe asthma requiring steroid treatment; a medical condition that may have influenced bone development, such as Type 1 diabetes mellitus and juvenile rheumatoid arthritis; and a known disorder of dietary behavior, such as anorexia and bulimia. Exclusionary status was determined via the girls’ reports on a health history questionnaire. If siblings were in the same troop, only the older girls’ data were included in the analyses. For twins, one girl was randomly selected. To mitigate any potential discomfort that the girls might experience due to being excluded from the study, girls who did not meet the enrollment criteria (n = 42) participated in the programs and completed the assessments, although their information was not included in the analyses. The excluded girls did not significantly differ from the study sample in terms of either race or age.

Of the initial sample of 395 eligible girls, 108 did not complete the 1-year follow-up assessment. The reasons were as follows: they did not want to continue (n = 56); they were lost to follow-up (n = 42); they were too busy or had a schedule conflict (n = 5); or the reasons were unknown (n = 5). The girls who dropped out of the study did not differ significantly from participants on race or age. An additional 40 girls were dropped from the data analyses because of missing data. Thus, the mean age of our sample was 9.35 years (SD = .59) at baseline, with the following distribution: 8-year-olds (n = 8), 9-year-olds (n = 151), 10-year-olds (n = 81), and 11-year-olds (n = 7). The racial background was 87.9% Caucasian (n = 217), 7.3% African American (n = 18), 0.4% Hispanic (n = 1), 1.2% Caucasian/African American (n = 3), 0.8% Caucasian/Asian (n = 2), 0.4% Caucasian/Hispanic (n = 1), 0.8% Caucasian/African American/ Other (n = 2), and 1.2% other multiracial (n = 3).

Procedure

Recruitment. From August 1998 to December 2000, information about the project was distributed to leaders of Girl Scout troops that had at least six girls between the ages of 8 and 11. Thirty-eight troop leaders were interested, and the 30 eligible troops were randomly assigned to one of three groups. For each sequentially recruited group of six troops, statistically generated random number blocks were used to assign two troops to each of the three arms: a control group (C), the behavioral intervention with girls only (I), and the behavioral intervention with girls and their mothers (IM). This block randomization procedure was employed because the number of troops that would eventually be enrolled was not known.

Following randomization of troops to treatment arms, parents were invited to a meeting to learn about the project. They were given packets containing a letter from the principal investigator, an information sheet describing the project, a letter of support from the chief executive officer of Girl Scouts of the council, a timeline, and a consent form. Parents and girls were invited to complete the assessment at the next Girl Scout meeting.

Data collection. After obtaining informed assent from the girls and written consent from their parents or legal guardians, participants completed a baseline assessment...
administered by research assistants and dietitians from the local county board of health. From December 1999 to May 2001, a 1-year follow-up assessment—with a range of 11 to 18 months (M = 12.7 months) after baseline—was conducted with girls and their mothers. Additional assessments were conducted for 2- and 3-year follow-ups. (This article includes the data from only the baseline and 1-year assessments.) Girls, mothers, and troop leaders were masked to their group membership assignment. However, because the project was called the Osteoporosis Prevention Project, some individuals in the control troops may have determined their status owing to the generic health focus of the sessions. Additionally, due to the nature of the project, there was no masking of the study facilitators or of those assessing the participants.

Study design and treatment. Participants in all three groups received six educational training sessions over a 3-month period. Specifically, sessions were delivered over a 6- to 33-week period (M = 13.1) for the C group; over a 6- to 20-week period (M = 13.8) for the I group; and over a 9- to 22-week period (M = 13.8) for the IM group. Each session lasted approximately 30 min, to hold the attention of this age group and to allow for usual troop activities. Trained research assistants, dietitians from the county board of health, and a licensed clinical psychologist presented the session materials for the intervention groups. Consistency of the presentation of materials was maintained according to a detailed manual, to supplementary materials such as overheads, and to scripted demonstrations (e.g., Jenga blocks to depict bone structure), as well as to videotaping of selected portions of sessions for training purposes. No adverse events were reported by any of the study participants.

Multicomponent behavioral–educational intervention. The targeted behavioral intervention program (I and IM groups), entitled “Know Bones About It,” was developed for this project and focused on skills training in enhancement of dietary Ca intake and WBPA. Strategies used to promote behavioral change in the girls included self-monitoring (with rewards for positive behavior), feedback on goal attainment, social persuasion, problem-solving training, role modeling, contracting, positive reinforcement, and practice of the desired behaviors (see Table I). For example, self-monitoring involved asking the girls to complete Ca star charts and WBPA star pyramids to track their dietary intake and frequency of a variety of physical activities. Small rewards, such as stickers, were given for returning completed charts. If the girls in a troop returned 80% of their star charts, star pyramids, and bone books for peer education—that is, the girls’ written and pictorial depictions of what they learned from the intervention program—they earned a pizza party. For practice of the desired behaviors, girls jumped rope for at least 15 min during the last four intervention sessions.

Sessions for the IM group were the same as they were for the I group, but mothers (or primary caregivers) attended two interactive sessions led by a psychologist, with an additional focus on maternal role modeling of eating Ca-rich foods; on engaging in an active lifestyle; on coaching—that is, praising their daughters for healthy choices and creating an environment with the necessary “equipment” for osteoporosis prevention, such as a variety of Ca-rich foods and exercise supplies; and on positive reinforcement for the girls’ reaching dietary and WBPA goals (Table I). Girls and mothers attended a portion of the second session together to learn problem-solving techniques and the reward system.

Control group. The control group received a healthy-lifestyles educational curriculum developed for this project. The purpose of this group was to control for any nonspecific effects from being educated about healthy lifestyles and from contact time and number of sessions (n = 6) with professionals during the Girl Scout meetings. Sessions included such elements as instruction on the food pyramid and lifestyle choice activities (see Table II). Girls in this group were given small educational items, such as stress balls in the shape of apples, to reinforce the content of sessions. Some brief mention

<table>
<thead>
<tr>
<th>Session</th>
<th>Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Overview of osteoporosis and healthy eating.</td>
</tr>
<tr>
<td>2</td>
<td>Prevention of osteoporosis and healthy food choices (i.e., high-calcium, low-fat foods).</td>
</tr>
<tr>
<td>3</td>
<td>Prevention of osteoporosis and WBPA; given jump ropes and taught jumping tricks and rhymes</td>
</tr>
<tr>
<td>4</td>
<td>Discussed barriers and problem-solving techniques; jumped rope.</td>
</tr>
<tr>
<td>5</td>
<td>Wrote individualized “bone books” for peer instruction; jumped rope.</td>
</tr>
<tr>
<td>6</td>
<td>Prepared high-calcium snacks; jumped rope.</td>
</tr>
</tbody>
</table>

*Girls’ written and pictorial depictions of what they learned from the intervention program were shared with Brownies.*
Table II. Topics for the Control Group (Healthy-Lifestyles Education Program)

<table>
<thead>
<tr>
<th>Session</th>
<th>Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Using the food guide pyramid.</td>
</tr>
<tr>
<td>2</td>
<td>Heart-healthy behaviors—for example, instructed to read food labels.</td>
</tr>
<tr>
<td>3</td>
<td>Choices for life—avoiding negative health habits, such as alcohol and cigarettes, and adopting healthy behaviors, such as seat belt use.</td>
</tr>
<tr>
<td>4</td>
<td>Activities and healthy eating—for example, role-played about challenging life situations.</td>
</tr>
<tr>
<td>5</td>
<td>Games on healthy eating and lifestyles—for example, word searches, scrambles, and crossword puzzles.</td>
</tr>
<tr>
<td>6</td>
<td>Prepared a healthy snack.</td>
</tr>
</tbody>
</table>

of the benefits of physical activity was included in the session on heart health.

Measures of Outcomes

Dietary assessment of Ca. The average daily dietary intake of Ca (mg) was assessed with an interviewer-administered food frequency questionnaire (FFQ) previously developed by Musgrave and colleagues (Musgrave, Giambalvo, Leclerc, Cook, & Rosen, 1989). This questionnaire covers 23 foods from the healthy diet pyramid that are rich in Ca or vitamin D. The Ca level from the FFQ correlated between \( r = .73 \) and \( r = .84 \) with 4-day food intake records in a sample of adult women (Musgrave et al., 1989). Reproducibility of Ca-intake scores over a 1-year period using a similar FFQ was .58 among older children and adolescents and even higher among females, .67, indicating that FFQs have a reasonable ability to assess the Ca intake of this age group over time (Rokett, Wolf, & Colditz, 1995). From baseline scores in this sample of 243 girls, the average Ca score was 1382.2 mg (SD = 661.0), with 50.6% meeting the RDA of 1300 mg.

WBPA assessment. The hours of physical activity per week were assessed using an interviewer-administered questionnaire for children (Fontvielle, Kriska, & Ravussin, 1993; Kriska et al., 1990). The interview format of the questionnaire allowed the girls to report the number of WBPA and non-WBPA performed on a regular basis over the course of the past year (adjusted for seasonal activities). Only total hours per week of WBPA were included in the present analyses. Girls who had exercised 2.33 hr per week (approximately 20 min per day) were considered to have met recommended levels because 20 to 30 min per day is the recommended amount of physical activity for adults (U.S. Department of Health and Human Services, 1996). The original data were highly skewed and kurtotic, so the data were collapsed into the following clinically relevant values for analyses: 0 (no WBPA), 1 (30 min or less), 2 (greater than 30 min to 1 hr), 3 (greater than 1 hr to 2 hr), 4 (greater than 2 hr to 4 hr), and 5 (more than 4 hr of WBPA per week). From the baseline scores of girls in this sample \( (N = 245) \), the average score was 2.53 (SD = 1.66), which is approximately 1.5 hours per week, with 30.6% of the sample meeting the recommended guidelines.

Data Analytic Plan

The issue of clustering. The sample consisted of 247 girls in 30 Girl Scout troops, and the unit of randomization for the intervention was a troop. Girls were nested within troops, resulting in a strong potential for clustering—that is, girls within troops would be more similar to one another than to girls between troops. Clustering violates the assumption of independence among observations (Bryk & Raudenbush, 1992). If sufficiently high, clustering needs to be accounted for using techniques such as general linear mixed models or hierarchical linear/logistic models (HLMs) to avoid making Type I errors owing to underestimating the variance (MacKinnon & Lockwood, 2003).

An intraclass correlation coefficient (ICC) was calculated to assess the degree of clustering for the outcomes, which provided an estimate of how much variance is due to the troop. An ICC (or \( r \)) can be calculated in a variety of ways, including by performing a one-factor ANOVA with the clustering group as the factor. The mean square estimates from this analysis can be used to calculate the ICC using the following formula (Slymen, Elder, Litrownik, Ayala, & Campbell, 2003):

\[
\rho = \frac{MS_{between} - MS_{within}}{MS_{between} + (m - 1)MS_{within}},
\]

where \( m \) is the average cluster size. Typically, ICCs for behavioral outcomes in a school environment vary from just above zero to around 7%, although ICCs as low as .0025 have been shown to represent sufficient clustering to warrant adjustment (Ennett, Flewelling, Lindrooth, & Norton, 1997). Typical ICCs for Girl Scout troops have not been established.

The ICC for change in Ca intake was 7.6 and was significant at \( p = .02 \). The ICC for baseline Ca intake was 2.9 and was not significant. The ICCs for WBPA were similar—7.9 for WBPA at follow-up (\( p = .02 \)) and the ICC for baseline WBPA was not significant. Given the high ICC for both of our primary outcomes and for the method of randomization (i.e., cluster randomization),
HLMs were used in all analyses to control for the clustering at the troop level using HLM for Windows 5.05 (Raudenbush, Bryk, & Congdon, 2001).

In general, HLM partitions the variance in the dependent variable into the effects that occur at the individual level from those at the troop level. HLM also allows for the inclusion of variables to predict the variance at multiple levels (i.e., the individual and the group). Since no specific hypotheses were developed to describe attributes at the troop level that would predict the outcome, hierarchical models were used solely to partition out the variance attributable to the troop. (For more extensive detail on HLM methodology, see Bryk & Raudenbush, 1992; Diprete & Forristal, 1994; Kreft & de Leeuw, 2000; Snijders & Bosker, 2000.)

The methods of Raudenbush and Liu (2000) were used to calculate statistical power for cluster randomization with the power and sample-size calculations based on the effect sizes of .44 for dietary Ca intake and WBPA. Using our final sample size (247) and the intraclass correlation coefficient for the Ca outcome, the study had 85% power to detect differences between the two groups.

**Hypothesis 1.** We hypothesized that girls in the intervention groups combined would report significantly greater increases in their Ca intake and in their WBPA levels from baseline to follow-up relative to controls. Hierarchical linear models were conducted with difference in Ca intake from baseline to 1-year follow-up as the dependent variable and with group membership (i.e., intervention vs. control) as the independent variable. For WBPA, a three-level hierarchical linear model was run using the self-reported WBPA (six categories) as the outcome and the assessment period (baseline and 1-year follow-up) as a repeated measure. The intervention effect (intervention vs. control) was the independent variable.

**Hypothesis 2.** We examined whether Hypothesis 1 would receive support when considering only girls who were not meeting recommended levels at baseline. Thus, a subanalysis was run on the girls who did not meet the recommendations at baseline, to determine whether girls were more likely to report eating the RDA of Ca (or more) at 1-year follow-up if they were in the intervention groups compared to the control group. Likewise, a similar analysis was conducted for recommended frequency of WBPA (20 min per day).

**Hypothesis 3.** We hypothesized that girls in the intervention group with mothers would have significantly greater improvements in Ca intake and WBPA compared to the other two groups. This hypothesis is parallel to Hypothesis 1, except that the independent variable for the intervention includes three groups (C, I, IM). Hierarchical linear models were run to determine if the IM group had significantly greater increases in dietary Ca intake (using a change score) and significantly higher WBPA controlling for baseline levels compared to the two other groups (I and C).

**Hypothesis 4.** We examined whether Hypothesis 3 would receive support when considering only girls who were not meeting recommended levels at baseline. Hypothesis 4 is parallel to Hypothesis 2, although the independent variable includes three groups (C, I, IM). This analysis tested whether girls in the IM group were more likely to meet or exceed the recommended levels of Ca and WBPA compared to the other two groups but among only those girls who did not meet recommendations at baseline.

**Results**

See Table III for the means and standard deviations of mg of Ca intake and WBPA at baseline and at 1-year assessment by group. The C group had significantly higher Ca intake at baseline compared to the intervention groups combined, \( t = -2.51; p = .03 \). The groups were not significantly different on WBPA at baseline. Based on listwise deletion-paired \( t \) tests, Ca scores from baseline \( (M = 1536.3, SD = 638.5) \) to 1-year follow-up \( (M = 1421.1, SD = 789.7) \) for the control group did not change significantly over time, \( t = -1.06, df = 75, p = .29 \). Ca scores from baseline \( (M = 1313.3, SD = 657.1) \) to 1-year follow-up \( (M = 1433.5, SD = 758.5) \) for the intervention group increased significantly over time, \( t = 2.24, df = 163, p = .03 \).

**Results Based on Hypotheses**

**Hypothesis 1.** The Ca intake-change score for girls in the intervention groups was 282.5 mg greater than it was for girls in the control group, which was a statistically significant difference between groups (unstandardized \( \beta = 282.59; SE = 133.21; t = 2.73; p = .03 \)). This is equivalent to a 205-ml serving of milk (about 8 fluid ounces). A model predicting Ca intake-change scores from baseline to follow-up that controlled for baseline Ca intake did not support this finding. In this model, the intervention group still had higher Ca intake-change scores compared to the scores of the control group at follow-up (158.1 mg), although this difference was no longer significant \( (p = .21) \). The incongruence between this and the former analysis appears to be clarified in the analyses testing Hypotheses 2.
versus 73.7% for the controls. Of the 21 WBPA categories followed up were 69.7% for intervention groups combined increased in their frequency of WBPA from baseline to percentages of girls who remained at the same level or Hypothesis 2. Contrary to expectation, the girls in the intervention groups who had not met or exceeded the recommended intake of Ca at baseline were not more likely than were the controls to meet or exceed recommendations at follow-up (odds ratio \([OR] = 0.61; CI = .31–1.18; p = .14\)). However, although not originally hypothesized, the girls who had met or exceeded the recommended intake of Ca at baseline were more than two times as likely to have maintained their Ca intake to meet or exceed the recommended intake at follow-up compared to controls who had met or exceeded the RDA of Ca at baseline \([OR = 2.31; CI = 1.0–5.34; p = .05]\). An interaction model was significant that included an interaction term for group membership (intervention vs. control) and baseline Ca intake, with the main effects (unstandardized \(\beta = .36; SE = .13; t ratio = 2.73; p = .01\)). Thus, the intervention was effective primarily for girls who had met or exceeded the RDA of Ca at baseline.

No support was found for the WBPA hypothesis. The girls in the intervention groups who did not meet the recommended levels of WBPA at baseline were not more likely to meet or exceed the recommended levels of WBPA at 1-year follow-up compared to controls who had not met or exceeded recommended levels of WBPA at baseline \([OR = .65; \text{confidence interval } CI = .33–1.29; p = .22]\).

**Hypothesis 3.** Contrary to our hypothesis, girls in the IM group did not have statistically significant greater increases in their Ca intake when compared to those in the I group, although Ca intake increased by 63 mg more in the IM group than it did in the I group \([SE = 105.7; t ratio = .60; p = .55]\). Hypothesis 3 was not supported for WBPA either, because girls in the IM group did not have significantly greater increases in their WBPA when compared to girls in the I group \([unstandardized \beta = .10; SE = .20; t ratio = .497; p = .62]\). The percentages of girls who reported either the same level or increases in their frequency of WBPA were 70.2% for the IM group and 69.0% for the I group.

**Hypothesis 4.** This hypothesis for better outcomes for girls in the IM group was not supported \([OR = 1.32; CI = .60–2.89; p = .49]\), because the percentage of girls in the intervention groups who had improved from baseline to meet or exceed the recommended Ca intake at follow-up were 29.7% for IM group and 35.8% for I group. Among girls who did not meet the RDA of Ca intake at baseline, those in the IM group demonstrated a larger increase \((M = 332)\) than did those in the I group \((M = 253)\); however, this difference was not significant \([SE = .84; t value = .95; p = .34]\). Hypothesis 4 was also not supported for WBPA. Girls in the IM group who had not met recommendations for WBPA at baseline were not more likely to meet or exceed recommendations at follow-up \([OR = .85; CI = .36–1.99; p = .70]\). Specifically, 15.4% of girls in the IM group versus 17.6% of girls in the I group who had not met recommended levels at baseline improved to meet or exceed the recommended frequency of WBPA.

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**Table III. Descriptive Statistics of Outcomes**

<table>
<thead>
<tr>
<th>Groups</th>
<th>Calcium intake (mg)</th>
<th>Weight-bearing physical activitya</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>1-year</td>
</tr>
<tr>
<td>Control (C)</td>
<td>M</td>
<td>1525.1</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>650.2</td>
</tr>
<tr>
<td></td>
<td>n</td>
<td>79</td>
</tr>
<tr>
<td>Intervention (I)</td>
<td>M</td>
<td>1324.3</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>680.4</td>
</tr>
<tr>
<td></td>
<td>n</td>
<td>70</td>
</tr>
<tr>
<td>Intervention with Mothers (IM)</td>
<td>M</td>
<td>1305.2</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>642.7</td>
</tr>
<tr>
<td></td>
<td>n</td>
<td>94</td>
</tr>
</tbody>
</table>

aValues determined by hours of weight-bearing physical activity per week: 0 (no WBPA), 1 (30 min or less), 2 (greater than 30 min to 1 hr), 3 (greater than 1 hr to 2 hr), 4 (greater than 2 hr to 4 hr), and 5 (more than 4 hr of WBPA per week).
Discussion

This RCT of a multicomponent behavioral–educational intervention—based in part on the model of social cognition for the primary prevention of osteoporosis with Girl Scouts—was successful at maintaining or increasing Ca intake for girls with higher intakes at baseline. At a time when Ca intake typically declines for preadolescent females (Alaimo et al., 1994), the ability to maintain adequate Ca intake is a promising outcome. Also encouraging is the potential for our intervention program to affect this particular eating behavior during a crucial time in bone development.

Overall, girls in the intervention groups demonstrated improvements in Ca intake compared to controls, but the groups were not significantly different when baseline intake was added to the analysis as a covariate. We believe that this lack of significance is explained by our subsequent finding that the intervention was only successful for girls who had higher Ca intake at baseline. Thus, our intervention lacked the potency necessary to improve dietary Ca intake among girls with low intakes at baseline. In an attempt to translate the changes in the girls’ Ca intake into dietary terms, we performed post hoc exploratory analyses of the girls’ dietary behavior (i.e., consumption of certain Ca-rich foods) comparing follow-up consumption between the intervention groups combined and the control group while controlling for baseline consumption. These analyses revealed no significant differences in reported consumption of milk, Ca-fortified orange juice, yogurt, or cheese.

We can only compare our findings with osteoporosis prevention programs designed for adult women because no published preventive behavioral interventions for children or adolescents could be located. A recent report of an educational intervention documented increased Ca intake of an average of 500 mg among those women not consuming adequate Ca at baseline (Blalock et al., 2002). We found slightly lower mean Ca increases of 252 to 332 mg among the girls in our intervention groups who were not consuming adequate Ca at baseline.

Our intervention programs—designed specifically to increase the frequency of girls’ WBPA for the prevention of osteoporosis—were not more effective than a generic healthy-lifestyles program. A trend existed for an increase in WBPA frequency for all of the groups. Although our interventions designed for preventing osteoporosis cannot be credited for these gains, these increases across all groups are a positive finding and merit some examination, as physical activity has been shown to decline over time among adolescent girls (Kim et al., 2002). Thus, even programs that promote healthy lifestyles for preadolescent girls may offer some benefits for the prevention of osteoporosis if WBPA levels are increased. Blalock and colleagues (2002) found no intervention effects for exercise, as we did as well in the present investigation. Finally, no incremental benefit was found for the intervention group with mothers for either Ca intake or WBPA, which may have been due to their limited participation (mothers attended only two of six sessions).

Limitations

Our results must be interpreted with consideration of the following limitations. The outcome behaviors were measured via self-report and may have been influenced by social desirability factors. More direct measures exist for assessment of physical activity levels, such as accelerometers, but these were not selected because they provide estimates of activity levels over a brief time period (typically 4 to 7 days) and do not account for seasonal variation, which is an important consideration in the geographic region in which this intervention study was conducted. Additionally, accelerometers do not provide any information on the type of activity performed. Observational methods have been employed to assess dietary intake in children, but these are often limited to one meal per day—school lunch. Another limitation was a potential for bias because those assessing the study participants were not masked to the group assignment of the troops. Finally, sampling issues may have limited the generalizability of our findings. Our sample’s baseline average of 1382 mg of Ca is quite a bit higher than the range of 700 to 950 mg per day reported for other community or school samples (Fleming & Heimbach, 1994; Weaver, 1994). This suggests that Girl Scouts may consume a more nutritious diet than the general population does, which is certainly a possibility as health and fitness form a national Girl Scout objective. No prior research on the Ca intake of Girl Scouts could be located, so whether our findings are typical for this community youth group is not known. Comparisons between Girl Scouts and other samples on physical activity levels are difficult because this investigation considered only weight-bearing activities, and other studies have reported rates for all physical activities combined. Also, our sample was predominantly Caucasian, so the efficacy of this intervention for ethnic minority groups is not known.

Recommendations for Future Studies

We do not know whether our intervention’s effectiveness for maintaining adequate Ca intake, rather than for improving Ca intake, among girls with lower intakes at
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baseline is a weakness of our intervention or an indication of the theory of social cognition. Data on potential mediators and moderators of the intervention, such as parental modeling and the girls' knowledge about osteoporosis, need to be examined to better explain our findings. Future research could also examine whether the lack of an incremental benefit of parental involvement was a result of too-limited time with parents by testing whether extended participation would be effective. Perhaps including parents in a greater number of sessions or adding incentives for parents' completion of assignments could further enhance the lifestyle improvements of the girls. Additional investigation could also determine whether any greater effects would be found for girls who were not meeting the recommended levels at baseline if sessions focused on tailoring strategies for integrating WBPA into the girls' daily schedules and for adding specific Ca-rich foods into their regular diets. We would consider the modification of our intervention programs for implementation into elementary schools to reach a larger population with more risk factors, such as low socioeconomic status, as well as to serve girls who may be adopting fewer healthy-lifestyle behaviors than do those who choose to join the Girl Scouts.

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