SUPPLEMENT

Effects of Dairy Product Consumption on Height and Bone Mineral Content in Children: A Systematic Review of Controlled Trials

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ABSTRACT

There is a physiological basis for the roles of selected nutrients, especially proteins, calcium, and vitamin D, in growth and development, which are at a maximum during the pediatric period. Milk and dairy products are particularly rich in this group of nutrients. The present systematic review summarizes the available evidence relating dairy product intake with linear growth and bone mineral content in childhood and adolescence. A search was conducted in the MEDLINE (via PubMed) and SCOPUS databases following Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and included intervention-controlled clinical trials with dairy products in children from 1 January, 1926 to 30 June, 2018. The risk of bias for each study was assessed using the Cochrane methodology. The number of study participants, the type of study and doses, the major outcomes, and the key results of the 13 articles included in the review are reported. The present systematic review shows that supplementing the usual diet with dairy products significantly increases bone mineral content during childhood. However, the results regarding a possible relation between dairy product consumption and linear growth are inconclusive. *Adv Nutr* 2019;10:S88–S96.

Keywords: body height, bone density, cheese, children, dairy product, growth and development, milk, yogurt

Introduction

The relation between milk consumption during the pediatric age period and increased linear growth and bone mineralization has been widely hypothesized since the 1920s (1). In addition to fetal development, the pediatric period is when the largest and fastest growth and development occur. This growth is continuous, with rate changes throughout childhood, i.e., accelerated growth during early childhood, stable growth during the preschool and school years, and accelerated growth during puberty (2). Height and bone mineral content (BMC) are known growth markers. Linear growth and bone acquisition are 2 different physiologic processes that do not occur exactly at the same time, although they are related (3). Skeletal mineralization begins during fetal development and continues at different rates until the end of the teenage years. At this point, 90–95% of the total peak bone mass has been reached, of which 40–45% develops during adolescence (4–7). McCormack et al. (3) studied a group of 2014 boys and girls and observed that at 7 y of age they had acquired between 69.5% and 74.5% of their adult height and only between 29.6% and 38.1% of their maximum BMC. At the time of their peak height velocity, these children had acquired almost 90% of their adult height and 57.6–60.2% of their maximum BMC. They also observed that between 6.9% and 10.7% of peak bone mass is gained in late adolescence, after the cessation of linear growth.

Genetic factors, sometimes mediated by hormonal factors, determine ∼70–80% of linear growth and acquisition of BMC (8–10), whereas environmental factors determine ∼20–30%, especially physical activity (11–13), inactivity and sedentarism, and diet (14–17). These exogenous factors are susceptible to change.

Regarding physical activity, it is shown that exercise improves muscle strength, cartilage preservation, and bone remodeling (18, 19). Studies in rat models (20, 21) and clinical trials in osteoporotic patients (18, 19) confirm that

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aerobic activity plus resistance or strength exercises (like whole body vibration training) are a great tool for improving bone mass.

In relation to the diet, understanding the roles of different food systems and patterns is important for establishing prevention and intervention strategies. Physiology justifies milk and dairy product consumption during the pediatric period, because they are good sources of energy, macronutrients, and micronutrients (proteins, phosphorus, magnesium, vitamin D, and, most importantly, calcium) for growth and development (15, 16). In addition, prospective clinical studies have shown that calcium supplementation can increase the acquisition of bone mass during childhood, adolescence, and early adulthood (17, 22). There is a threshold in the calcium intake, which if exceeded does not affect the bone mass, but if the consumption is below the threshold it results in a negative balance. The level of this threshold depends on the ability to absorb calcium efficiently and decrease urinary losses and varies according to age, ethnic group, and genetic factors (23). Moreover, dairy product consumption increases the secretion of insulin-like growth factor type I, which benefits skeletal development (24). Likewise, dairy products are thought to aid in calcium absorption because of their lactose and casein phosphorylated peptides and because they allow calcium intake to be more homogeneously distributed in relatively small amounts throughout the day (25). Currently, in developed countries, children under the age of 9 y are recommended to use ∼500 mL dairy products and adolescents >600 mL dairy/d (26).

Since the first studies on dietary supplementation with milk (1), the scientific community has continued to study its potential benefit, with the goal of adopting public health policies to optimize pediatric growth and development (27–29). The development of dual-energy X-ray absorptiometry (DXA) equipment since the 1960s has allowed for evaluating BMC as well as density in growth studies (30). This technique showed that children worldwide could improve their bone mass peak via calcium or milk supplementation (14, 27, 31). However, these findings were inconclusive. Two meta-analyses performed by Huncharek et al. (32) in 2008 and Beer (33) in 2012 shed light on this topic. However, current evidence on the association of dairy product consumption with growth and BMC has not been synthesized. Therefore, the present systematic review carried out an updated evaluation of the available evidence from clinical trials that correlate dairy product intake with linear growth and BMC in the pediatric population.

Methods

The present review was prepared following the guidelines for Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (34) and was registered in the International Prospective Register of Systematic Reviews (PROSPERO) as CRD42018100083. The PICOS criteria (Population, Intervention, Comparison, Outcomes, Settings) (35) were used (**Table 1**) to elaborate the following review question: does the intake of dairy products influence linear growth and BMC in children and adolescents? Controlled intervention studies that evaluated dairy product intake and its relation with BMC and height in children and adolescents were incorporated.

Inclusion and exclusion criteria

Children and adolescents ≤18 y of age and of any ethnic origin were included. Controlled studies, randomized or not, published from 1 January, 1926 to 30 June, 2018, were incorporated into the review. Studies that used dairy fractions, did not include linear growth or BMC data, or did not compare a control group without dairy products were excluded.

Intervention types

Studies in which the interventions were performed with complete dairy products (not fractions) and were compared with a nonsupplemented group were included. The articles were not restricted by time, type, or amount of dairy in the intervention.

Primary outcome measures

Height in centimeters and changes in height after the intervention in centimeters, centimeters per year, or percentage were included as valid measures for linear growth analysis. To evaluate bone mineralization, the BMC in grams and its modifications in grams per year or percentage were considered.

TABLE 1 PICOS criteria (35) for including studies that evaluate the influence of dairy product intake on linear growth and BMC in children and adolescents

Parameter	Inclusion criteria
Population	<18 y
Intervention	Controlled dairy intake
Comparison	Control
Outcome	Height and BMC
Setting	Controlled trials

[1] BMC, bone mineral content.

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Abbreviations used: BMC, bone mineral content; DXA, dual-energy X-ray absorptiometry; MeSH, Medical Subject Headings.

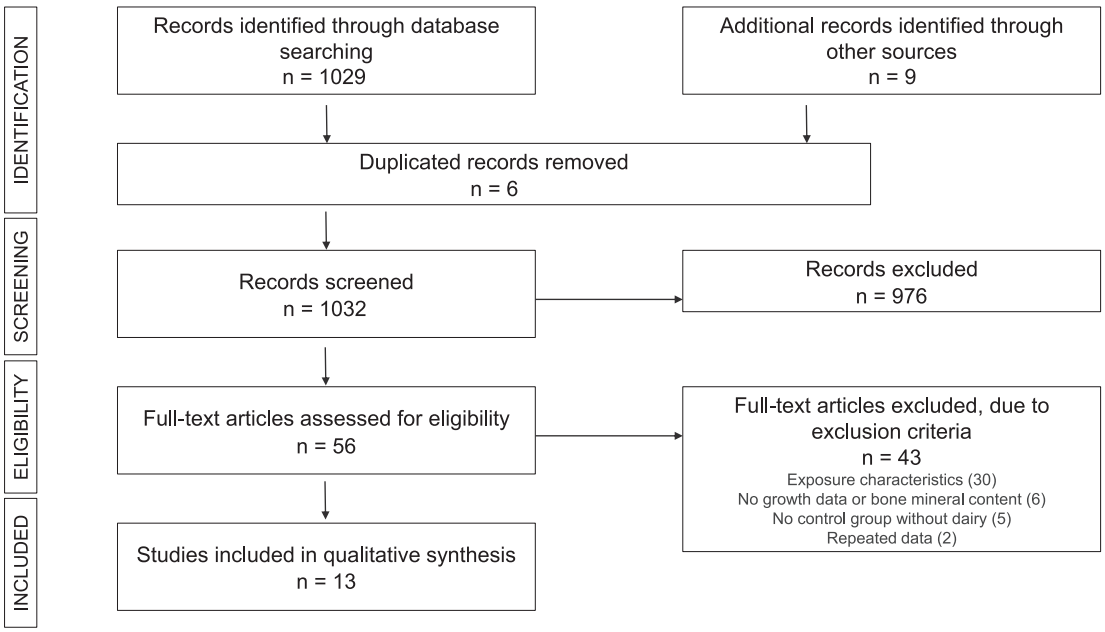

FIGURE 1 Flow diagram of the literature search process.

Literature search

The PUBMED and SCOPUS databases were searched using the Medical Subject Heading (MeSH) terms "dairy products," "growth," "development," "bone density," and "height."

In PUBMED the following search strategy was used: "Dairy products" (All Fields) AND ["Growth and development" (All Fields) OR "Growth" (All Fields) OR "development" (All Fields) OR "bone density" (All Fields) OR "body height" (All Fields)] AND {"humans" [MeSH Terms] AND ["infant" (MeSH Terms) OR "child" (MeSH Terms) OR "adolescent" (MeSH Terms)]}. SCOPUS was searched using the following formula, excluding from the results the studies indexed in MEDLINE and those on animals: "Dairy products" AND ("Growth and development" OR "Growth" OR "development" OR "bone density" OR "body height").

Study selection

Independently, 2 authors (MJdC and CdL) selected the studies from the 56 articles reviewed in full. RL, MLC, AG, and MG-C arbitrated the discrepancies when no consensus on the selection was reached. Finally, 13 articles (36–48) were included in the systematic review.

Data extraction

Two investigators separately extracted the following data from each study: publication year, number of participants by sex, age, study type, intervention characteristics and study duration, and outcomes and conclusions. RL moderated any discrepancies.

Assessment of risk of bias

Two evaluators independently studied the risks of bias following the methodology of the Cochrane Collaboration (49). The articles were analyzed individually, and their risk of bias was classified as high, uncertain, or low depending on random sequence generation (selection bias), allocation concealment (selection bias), blinding of participants and personnel (performance bias), blinding of outcome assessment (detection bias), incomplete outcome data (attrition bias), and selective reporting (reporting bias). The presence of other additional biases was also analyzed. In cases with a disparity of opinions, a third reviewer arbitrated.

Results

Figure 1 shows the results of each step of the bibliographic search. Of the 1038 results from the first search (PUBMED, 448; SCOPUS, 581; and other sources, 9), 6 duplicate articles and 976 after review of the abstract were eliminated. Fifty-six articles were considered for evaluating the full text. Finally, 13 articles that met the inclusion criteria were included in this systematic review (36–48).

Tables 2 and **3** present the main characteristics of the selected clinical trials. The publication dates covered 1926 to 2017, with 7 articles published after 2000. The articles in this review included 3895 children and adolescents (63.67% female). In 5 of these studies (38, 40, 43–45), only girls participated. The sample sizes ranged from 47 to 757 participants, with a mean ± SD of 299 ± 234 participants. The mean age was 9.95 y, ranging from 3 to 18 y. Five articles (36, 38, 39, 43, 46) performed interventions using dairy products (between 0.9 and 1.2 g of calcium-equivalent doses per day) and the other 8 studies exclusively used milk. The

TABLE 2 Controlled trials with dairy product interventions to evaluate the effects on body height in 3895 children and adolescents[1]

Reference	*n*	Age,[2] y	Intervention	Type and time of intervention	Outcome	Results[3]	Conclusion
Vogel et al. (36)	240 (154F)	11.8 ± 1.5	Dairy (3 servings/d—0.9 g Ca/d)	RCT, 18 mo	Linear growth (cm)/year	Linear growth (cm)/y: IG: 4.43 ± 0.23; CG: 4.95 ± 0.25	Significantly less increase in annual growth
Lien et al. (37)	454 (237F)	7–8	Cow milk (500 mL/d; 6 d/wk)	RCT, 6 mo	Linear growth (cm)	Linear growth (cm): IG: 3.6 ± 4.8; CG: 3.2 ± 5.6	Significant increase in age-adjusted height
					Height-for-age change	HAZ: IG: 0.18 ± 0.92; CG: −0.25 ± 1.67	
Cheng et al. (38)	195 (195F)	10–12	Low fat cheese (1 g Ca/d)	RCT, 24 mo	Linear growth (cm)	Linear growth (cm): IG: 9.1 ± 0.3; CG: 9.1 ± 0.3	No significant differences
He et al. (39)	402 (217F)	3–5	Yogurt (125 mL/d; 5 d/wk)	RCT, 9 mo	Linear growth (cm)	Linear growth (cm): IG: 5.43 ± 0.69; CG: 5.24 ± 0.76	Significant increase
Du et al. (40)	757 (757F)	10	Cow milk (300 mL/d)	CT, 24 mo	Linear growth (cm)	Linear growth (cm): IG: 13.4; CG: 12.2	Significant increase in percentage of change
Lau et al. (41)	344 (143F)	9–10	Skimmed milk powder (40 g/d)	RCT, 18 mo	Linear growth (cm)	Linear growth (cm): IG: 7.11 ± 0.19; CG: 7.06 ± 0.17	No significant differences
Grillenberger (42)	554 (241F)	7.1	Cow milk (200 mL/d)	CT, 23 mo	Linear growth (cm)	Linear growth (cm): IG: 10.31 ± 0.33; CG: 10.04 ± 0.34	Significant increase in children with a baseline HAZ below the median
					Height-for-age change	HAZ: IG: 0.55 ± 0.05; CG: 0.4 ± 0.06	
Merrilees et al. (43)	105 (105F)	15–18	Dairy (1 g Ca/d)	RCT, 24 mo	Linear growth (cm)	Linear growth (cm): IG: 1.3; CG: 1.6	No significant differences
Cadogan et al. (44)	82 (82F)	12.2 ± 0.3	Cow milk (568 mL/d)	RCT, 18 mo	Linear growth (cm)	Linear growth (cm): IG: 8.8 ± 3.78; CG: 8.2 ± 2.95	No significant differences
Chan et al. (45)	48 (48F)	9–13	Dairy (1.2 g Ca/d)	RCT, 12 mo	Linear growth (cm)	Linear growth (cm): IG: 5.2 ± 1.6; CG: 5.3 ± 1.2	No significant differences
Baker et al. (46)	581 (253F)	7–8	Cow milk (190 mL/d)	RCT, 21.5 mo	Linear growth (cm)	Linear growth (cm): IG: 9.46 ± 1.68; CG: 9.18 ± 1.67	Significant increase in percentage of change
Lampl and Johnston (47)	86 (24F)	7.7–13	Cow milk (250 mL/d)	RCT, 8 mo	Linear growth (cm)	Linear growth (cm): IG: 3.45 ± 0.14; CG: 1.75 ± 0.17	Significant increase in age-adjusted height
					Height-for-age change	HAZ: IG: 0.87 ± 0.13; CG: −1.37 ± 0.1	
Morgan et al. (48)	47 (24F)	7–15	Cow milk (284 mL/d)	CT, 14 wk	Linear growth (cm)	No data	No significant differences

[1] CG, control group; CT, controlled trial; F, female; HAZ, height-for-age *z* score; IG, intervention group; RCT, randomized controlled trial.
[2] Values are ranges, means, or means ± SDs, as reported in the studies.
[3] Values are means, or means ± SDs, as reported in the studies.

TABLE 3 Controlled trials of dairy product interventions to evaluate effects on BMC in 1771 children and adolescents[1]

Reference	*n*	Age,[2] y	Intervention	Type and time of intervention	Outcome	Results[3]	Conclusion
Vogel et al. (36)	240 (154F)	11.8 ± 1.5	Dairy (3 servings/d—0.9 g Ca/d)	RCT, 18 mo	Change (g/y)	Total BMC: no data; spine: no data; femur: no data; radius: no data; tibia: no data	Significant increase in BMC at the tibia
Cheng et al. (38)	195 (195F)	10–12	Cheese (1 g Ca/d)	RCT, 24 mo	Change (%)	Total BMC: IG: 38.1; CG: 35; total femur: IG: 25.9; CG: 26.2; Lumbar spine: IG: 34.2; CG: 34	No significant differences
Du et al. (40)	757 (757F)	10	Milk (300 mL/d)	CT, 24 mo	Grams	Total BMC: IG: 1875.6 ± 281.3; CG: 1854.4 ± 268.4	Significant increase in percentage of change in total body BMC
Lau et al. (41)	344 (143F)	9–10	Milk (250 mL/d)	RCT, 18 mo	Change (%)	Total BMC: IG: 18.46 ± 0.67; CG: 16.88 ± 0.6; total hip: IG: 25.89; CG: 22.77; femoral neck: IG: 13.16; CG: 10.64; spine: IG: 21.51; CG: 19.23	Significant increase in BMC at the hip
Merrilees et al. (43)	105 (105F)	15–18	Dairy (1 g Ca/d)	RCT, 24 mo	Change (grams)	Total BMC: IG: 168.9 ± 24.7; CG: 167.4 ± 16.2; lumbar spine: IG: 3.83; CG: 2.58; femoral neck: IG: 0.12; CG: 0.06; trochanter: IG: 0.75; CG: 0.24	Significant increase in BMC at the trochanter
Cadogan et al. (44)	82 (82F)	12.2 ± 0.3	Cow milk (568 mL/d)	RCT, 18 mo	Change (%)	Total BMC (%): IG: 27; CG: 24.1; total BMC (g): IG: 428; CG: 391	Significant increase in percentage of change in total body BMC
Chan et al. (45)	48 (48F)	9–13	Dairy (1.2 g Ca/d)	RCT, 12 mo	Change (%)	Total BMC (g): IG 1695 ± 317; CG: 1617 ± 152; total BMC (%): IG: 14.2 ± 7.0; CG: 7.6 ± 6.0	Significant increase in percentage of change in total body BMC

[1] BMC, bone mineral content; CG, control group; CT, controlled trial; F, female; IG, intervention group; RCT, randomized controlled trial.
[2] Values are ranges, means, or means ± SDs, as reported in the studies.
[3] Values are means, or means ± SDs, as reported in the studies.

intervention period ranged from 14 wk for Morgan et al.'s (48) study in 1926 to 24 mo for those of Merrilees et al. (43), Du et al. (40), and Cheng et al. (38), with a median intervention period of 16 mo.

Dairy intake and height

All studies included in the review provided linear growth data (Table 2). Six studies showed significant changes in height adjusted for age (which relates the height with that corresponding to the age of the child in a reference population) or percentage change in height favoring the intervention group (37, 39, 40, 42, 46, 47). Among these, Grillenberger's study (42) found significant differences in *z*-score changes for height adjusted for age, but only in patients who were short in stature for their age at the baseline. The remaining articles showed no statistically significant differences in height after the intervention (36, 38, 41, 43–45, 48). Four (38, 43–45) of the 5 articles that included only girls (38, 40, 43–45) found no statistically significant differences in height; however, in the studies that included both boys and girls, 5 (37, 39, 42, 46, 47) of 8 (36, 37, 39, 41, 42, 46–48) found significant differences in height. Nevertheless, the studies that analyzed the subgroups by sex demonstrated no significant differences in height change between the sexes (36, 37, 39, 41, 42, 46–48). None of the articles that used dairy products rather than milk (36, 38, 39, 43, 48) showed significant differences favoring the intervention in height. In addition, the study with dairy products published by Vogel et al. (36) concluded that individuals in the intervention group grew significantly less than those in the control group.

Dairy intake and BMC

Changes in BMC were evaluated in 7 articles (36, 38, 40, 41, 43–45) (Table 3). BMC was assessed by DXA in all of them. All articles included data on total body BMC (36, 38, 40, 41, 43–45); 4 of the 7 studies (36, 38, 41, 43) included femur determinations, 2 total femur (36, 46), 1 femoral neck (41), and 1 femoral neck and trochanter (43); and 3 (38, 41, 43) included column measurements, 1 total (41), and 2 (38, 43) of the lumbar spine. One study included measurements in total hip (41) and another in radius and tibia (36). Six articles (36, 40, 41, 43–45) found significant differences in BMC levels: total BMC (40, 44, 45), tibia (36), total hip (41), or trochanter (43). One of these studies, which recruited 10- to 12-y-old girls, found no significant differences in total body, total femur, or lumbar spine BMC after the intervention. However, statistically significant differences in bone mineral density were found at the femur level (38).

Assessment of risk of bias

Fifty-four percent of the articles presented low risks of selection bias (random sequence generation) and attrition bias (incomplete outcome data); 25% had low risks of performance bias (blinding of participants and personnel) and detection bias (blinding of outcome assessment). In 77% of the articles, the risk of information bias (reporting bias) was uncertain, because they published nonsignificant data. The risk of selection bias (allocation concealment) was high in all participating articles. A high risk of attrition bias was considered when there were no references in the study to the data lost during the intervention and an evaluation of whether they were relevant, when the proportion of missing data was sufficient to have a clinically significant effect, or the methods of imputation for the treatment of missing data were used inappropriately. Other risks of bias included a short intervention time (48) of 14 wk and stratification through self-reported physical activity level questionnaires (38).

The article published by Lien et al. (37) presented the lowest risk of bias, although its mechanism of random assignment by collectivities and not individuals implies a significant risk of bias. The studies with the highest risks of presenting biased results were those of Morgan et al. (48) and Grillenberger (42). Additional information on the risk of bias analysis (a risk of bias graph and summary) of the analyzed articles is included in **Supplemental Figures 1** and **2**.

Discussion

The present systematic review of controlled trials on the effects of dairy product consumption on linear growth and BMC during the pediatric period shows that supplementing the usual diet with these foods significantly increases BMC. However, the results regarding a possible relation between dairy product intake and height are inconclusive.

Regarding the impact of dairy consumption on linear growth, 6 studies (37, 39, 40, 42, 46, 47) revealed statistically significant increases in the sizes of children whose ages ranged from 3 to 10 y. Five of these studies had the largest sample sizes, between 454 and 757 participants (37, 39, 40, 42, 46). However, 7 studies observed no significant differences (36, 38, 41, 43–45, 48), although the sample size was very low in 5 of them (43–45, 47, 48), 105, 82, 48, 86, and 47 participants, respectively, which could decrease the statistical power of the data analysis, and these included older children (9–18 y of age). Therefore, the linear growth rates, amount of milk supplemented (specifically calcium), and duration of the intervention were too heterogeneous to draw firm conclusions. These inconclusive results are consistent with the scientific literature that assesses the relation between calcium supplementation (the main micronutrient in milk involved in bone metabolism) and bone length, which has not evidenced a clear benefit of calcium intake on size during growth periods (15, 16, 24). In 2011, a meta-analysis was published addressing this question, which suggested an additional 0.4 cm/y increase in height for every 245 mL of milk consumed per day, although the degree of evidence was considered of moderate quality because most of the included studies presented serious limitations in their design and execution (33).

In selected populations with high malnutrition indexes (40, 42) and mainly vegetarian diets, an increased final size was observed after dairy product supplementation, which could be explained by the contributions of additional energy and high-biological-value proteins. One group (42) evidenced this effect specifically in the subset of children who

started with a lower height-for-age *z* score at the beginning of the intervention, which could support this hypothesis, although this may not have been adequately explored in the articles cited. Nevertheless, 1 cohort study by Marshall et al. (31), not included in the review, also suggested a relation between milk consumption and height increase, although in this case the children who participated belonged to families of medium socioeconomic status, with low risks of malnutrition. However, this relation was nonlinear; therefore, the mechanism that could explain the beneficial effect could not be attributed exclusively to this dietary measure but may link to a more favorable environment involving other unevaluated factors. In this sense, recent studies (50, 51) relate dairy product consumption to a healthier diet. Thus, a study conducted in Australia in 2012 on 222 children between 8 and 10 y old and involving 3 food recalls concluded that adequate dairy product consumption was associated with highly nutritious diets (50). Moreover, 1 study followed 1991 children from 8 European countries for 4 y and concluded consuming dairy products (milk, yogurt, and cheese) as snacks is associated with higher diet quality. Consuming dairy products outside of regular meals may be a good strategy for improving energy balance throughout childhood (51).

Regarding bone mineralization and dairy product consumption, 7 controlled trials were evaluated (36, 38, 40, 41, 43–45), of which 6 (36, 38, 41, 43–45) were randomized. Six of the 7 mentioned studies, 1 nonrandomized, showed positive relations with bone mineralization (36, 40, 41, 43–45), although this was measured in different locations: 3 at the total body level (40, 44, 45), 1 in the pelvis (41), 1 in the trochanter (43), and 1 in the tibia (36). These results were consistent with other investigations, which, conversely, studied the effect of avoiding milk consumption for prolonged periods. Black et al. (52) recruited 50 children between 3 and 10 y of age, who, for different reasons, ingested no milk (lactose intolerance or lifestyle) and observed that these children had significantly lower bone mineral densities and more fractures than did controls that consumed 200 mL of milk daily. However, the blood calcium concentrations in this group were lower, as an association between these concentrations and the *z* scores, as shown by DXA, was found only at some skeletal sites, suggesting that intakes of both calcium and other nutrients in milk are essential to properly mineralize bones. Studies supporting the benefits of milk or dairy products on bone show a significant inverse association between dairy food intake and bone turnover markers as well as a positive association with BMC (25, 53).

One study in the present systematic review further explored this hypothesis by comparing the effect of calcium supplementation on girls between 10 and 12 y old, either by administering pills or by increasing cheese intake (38). Both measures increased bone mass compared with the placebo, and this effect was greater in the group that received the food, although it was only statistically significant at the level of the tibial cortical bone. In addition, studies conducted on adults have also supported the hypothesis that dairy products ingested during childhood improve bone mineralization, and adults who consumed more milk in childhood had better bone density (17, 22).

However, demonstrating the true effects of improved BMC on individual health has not been possible. A 22-y prospective observational study concluded that high dairy intake during adolescence did not appear to prevent bone fractures in women during adulthood. In men, it appeared to be more of a risk factor, although the association was attenuated when weight was added to the model (54). Although observational studies only suggest hypotheses, and multiple factors influence the risk of fractures, knowing the long-term results of dairy supplementation interventions would be interesting. Likewise, the studies included in this review seemed to have short intervention times (between 14 wk and 2 y) compared with a study that evaluated dairy intake over 5 y (54).

Regarding sex, the present review found that studies on girls obtained less significant results for height than did those on both boys and girls, but studies using both sexes showed no differences between the sexes. Some cohort studies that included both boys and girls found statistically significant differences in height relative to dairy intake but also found no differences between subgroups by sex (31, 55). However, a study on height in adult males from 48 European countries found that the ratio of high-quality protein intake, especially from dairy products, to low-quality proteins from wheat was the most important factor in the secular improvement of height (56). Therefore, more studies including men or larger studies including both sexes should be designed to better evaluate the possible differences.

In the present review, we analyzed evidence from the last 92 y of intervention studies on the effect of milk and dairy products on linear growth and BMC in children. When evaluating the risk of bias in each of the studies and assessing their results, not all biases should be considered equally relevant. For example, for the intervention characteristics and results evaluated, we believe that performance bias is less important because height and BMC are objective data (objective measures). Conversely, the most relevant bias risks in this review appeared to be random sequence generation or selection bias, detection bias, and attrition bias.

Further studies should include male populations, unify anatomical sites for determining bone mineralization, and improve the blinding methods, although it is difficult to blind dairy food supplementation, but the risk of bias would be lower. Research comparing the effects of calcium from milk with those of isolated calcium supplementation should be continued.

Although no conclusive data exist relating the influence of milk and dairy products to linear growth, data related to improving bone mineralization after milk and milk product supplementation indicate that dairy products are important for proper bone health beginning in childhood.

Conclusion

The data obtained in the present review support the dietary guidelines (26) on the importance of children regularly consuming dairy products to ensure or improve their bone health. An increase of BMC is observed when the usual diet is supplemented with dairy products. This is especially important during this period of life at a time when consumption of this traditionally basic food in children's diets, particularly in Western countries, is decreasing due to lifestyle changes that favor intake of fast food, soft drinks, or plant seed–based beverages. Future research should be oriented towards realizing randomized controlled trials of appropriate sample size and adequate power, long-term interventions, and deep analyses of cohort studies in children beginning in early life.

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