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Research Article

Increased Milk Consumption May Improve Body Composition and Bone Health Among Pre-Pubertal Children

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Abstract

The objectives of the study were to examine linear growth, body composition and bone mineral status of pre-pubertal children participating in the "Milk for Schools programme" over one year. The control group was recruited from schools that were not participating. This prospective study followed 118 pre-pubertal children (5-10 years old) over one year. Body composition as well as whole body (WB) headless bone mineral content-(WB-BMC), bone mineral density (WB-BMD), lumbar spine BMC and BMD were measured with dual energy x-ray absorptiometry (Discovery A, Hologic, WI, USA). Anthropometric data including height, weight and waist circumference (WC) were collected. The total sample consisted of 58 children in the control group (C's) and 60 in the milk group. At baseline, the milk group was significantly older, taller and had higher WB-BMD. There were no significant differences between the groups over one year for change in height, weight, BMI z-score, WC, WB-fat and lean body mass (LBM). There was a significant treatment*time interaction for WB area ($p = 0.046$) and a marginally significant on WB-BMC ($p = 0.051$) and BMC z-score ($p = 0.093$). The changes in WB-BMC, WB-BMD and z-score over one year were significantly associated with change in LBM ($p < 0.001$). WB fat mass was significantly associated with WB-BMC ($p < 0.001$). LBM and WB fat mass significantly predicted children's bone health. The changes in WB- BMC and WB area were greater in the milk group over the year, with the BMC z-score increasing in the milk group but remaining stable in the controls.

Keywords: *Milk; Children; Bone; Body Composition; Food Frequency Questionnaire*

Abbreviations

BMD: Bone Mineral Density; BMC: Bone Mineral Content; WB: Whole Body; LBM: Lean Body Mass; DXA: Dual X-Ray Absorptiometry; BF: Body Fat; ANOVA: Analysis of Variance; BMI: Body Mass Index; LS: Lumbar Spine; MOH: Ministry of Health

Introduction

Attaining height potential is the result of the interaction between genetic background and macro-/ micronutrient availability during the growth period [1]. It is well known that deficiencies in vitamin D and calcium can affect bone development and growth [2]. Peak bone mass is the highest bone mass achievable within a person's genetic potential, and is usually accrued during adolescence [1]. Up to 90% of peak bone mass is accrued by the age of 18 years, although bone mass can still increase up to the third decade of life.

In white children, research has shown that the average skeletal calcium retention at the peak rate of accretion is 325 mg/day for girls and 409 mg/day for boys [1-3]. Due to the significant growth at this time, any modulation of accretion could affect lifelong bone health.

Early studies conducted in Caucasian [4-6] and Gambian children [7] showed that supplementing the diet with calcium or milk to increase nutrient intake may enhance bone accretion. In one study, girls who had their diet supplemented with milk had higher circulating IGF-1 concentrations, which may affect bone growth [6]. When extra phosphorus was provided, bone area as well as vertebral height increased and total BMC also increased. In another study, the diet of eleven year old white girls was supplemented with dairy products to the level of 1200 mg calcium per day for 12 months. The increased intake of dairy provided not only calcium but protein and other minerals plus additional vitamin D. After one year the intervention group had significantly greater increases in lumbar spine bone density and total body mineralisation [8].

More recent data also support an association between dairy consumption, growth, and bone health. Bone changes over two years in young children with a history of milk avoidance were evaluated, and results demonstrated persistent height reduction, obesity and low bone density at the ultradistal radius and lumbar spine [9]. In contrast, other authors have suggested that dairy or calcium intake may only be beneficial to specific subpopulations of children, or may actually fail to provide any benefit to children at all. In a meta-analysis on the relationship between dairy and calcium intake and BMC, a review of 21 studies concluded that increased dairy/calcium intake with or without vitamin D improved spine and whole body mineral content, but only in children with low baseline intakes of dairy or calcium [10]. Lanou., *et al.* [11] reviewed the evidence for the effects of calcium and dairy products on bone health of children and adolescents, and found no consistent benefits of increasing dairy consumption for child or young adult bone health.

The main purpose of this prospective observational study was to assess the relationship between bone health with dairy intake and body composition over one year, in pre-pubertal school children living within the Manawatu district, New Zealand.

Primary outcomes were

- Anthropometry: Weight (kg), height (cm), waist circumference (cm), BMI, whole body fat mass (WB-Fat) (kg), lean body mass- WB-lean (kg), and % body fat.
- Bone density: Whole body bone mineral density (WB-BMD) and whole body bone mineral content (WB-BMC) were measured.

Materials and Methods

Subjects

Recruitment process

Pre-pubertal children aged 5 - 10 years living within the Manawatu region, New Zealand, were recruited to take part in the current study. The study was approved by Southern A Human Ethics committee: 14/02 and 15/03. A total of 118 children participated in this study. Once the parent/guardian's permission was attained via a signed consent form, a health screening questionnaire was filled out and a visit to the Human Nutrition Research Unit at Massey University was arranged. On arrival to the human nutrition research unit, the children also signed their informed assent forms.

Participants involved

118 children ranging from 5 to 10 years of age were included in this study. The children were recruited from primary schools that participated in the "Milk for Schools" programme where they received received 200 mL of reduced fat (1.5% fat) milk (UHT) (Anchor™, Fonterra Cooperative Ltd, Auckland, New Zealand) per school day during school terms of regular milk (UHT) (Anchor™, Fonterra Cooperative Ltd, Auckland, New Zealand) per day during school terms. The controls were children that did not drink the milk at school or children from schools that did not participate in the programme. All children were brought to the Human Nutrition Research Unit at Massey University, Palmerston North where the bone density (DXA) scans and anthropometric measurements were taken. The food frequency questionnaire was also completed by each child under supervision. All measurements were undertaken by the same person except for DXA scans which were performed by a qualified technician. Standard procedures were carried out and all measurements were taken in the metric form (cm and kg). The children wore very light clothing with no shoes.

Inclusion criteria

The inclusion criteria were that the children were healthy and pre-pubertal. They were fluent in speaking and understanding English and the caregiver of the child would also understand English and must be over 18 years of age to provide informed consent.

Exclusion criteria

A health screening questionnaire was completed by the guardian of each child and children suffering from any medical condition that would alter bone metabolism were excluded from this study. These conditions could be diagnosed bone, gastrointestinal or renal disorders as well as diabetes. Furthermore, children consuming any medication that interferes with bone homeostasis were also excluded.

Anthropometry

Height: The height of each child was measured using a calibrated wall mounted stadiometer. Two measurements were taken per child and the average was used as the final value. In case of a difference > 1cm between the two readings a third measurement was taken and used.

Weight: A mechanical spring weighing scale was used to measure the weight of every child. Similar to height, two measurements were taken for weight and the average was used, however, if the difference between the recorded values was > 0.1 kg, the third measurement was used.

Waist circumference: The waist circumference was measured by placing a measuring tape slightly above the hip bone at the abdomen. At the time of measurement the abdomen was bare and children were asked to breathe normally. Two measurements were taken and an average was used, but in case of a difference of >1cm, a third value was recorded.

Frequency of consumption of milk and milk products

Milk and milk product consumption data was collected via a questionnaire. All research assistants were trained in delivery of the questionnaire and props were used to help the children understand portion sizes.

Dual energy x ray absorptiometry (DXA)

DXA scans were done on a Discovery A bone densitometer (Hologic, WI, USA). Whole body bone mineral density (WB-BMD) and bone mineral content (WB-BMC) were measured. Body composition including the lean body mass, total fat mass, and percent body fat (% BF) were also determined from the total body DXA scan.

The scans (excluding the head) were analysed by a qualified technician who followed the quality control protocol. Based on the manufacturer's instructions, quality control scans were performed everyday using a certified calibration block (calibration values accepted when co-efficient of variation was below 0.05%). A z score of 0 was equivalent to the mean and children with z scores equal to or less than -2 standard deviation were categorised as having low bone mineral density or low bone mass.

Follow-up

All children were followed up within one year of the baseline scan. All measurements were repeated as per the methodology outlined above.

Statistical Analyses

One-way ANOVA for the effect of treatment at baseline. Baseline results are presented as means and standard deviation, as well as a p-value for the effect of treatment. Repeated measures analysis of variance was performed using a mixed models approach (Proc mixed, SAS 9.3). The model includes treatment, visit, and their interaction as fixed effects and either age at baseline, school, and gender as blocking factors, or height as a covariate. Results are presented as least-squares means and 95% confidence interval, as well as p-values for the effects in the model.

Results

Basic demographic and anthropometric data

Children (n = 118) included in this study were residents of the Manawatu region, North Island, New Zealand. All participants were pre-pubertal with ages ranging from five to 10 years. The total sample consisted of 42.4% males and 57.6% females. Children from five schools were enrolled. All schools had control children, but only two of five schools had children in the milk group. For the Milk schools, the majority of the children received the milk and only about one quarter of children were in the control group. Subjects were between 5 and 10 years old at the start of the trial with the majority being 8 yrs old (approx. 45%). On average the age in the control group was 7.6 years compared to a slightly higher 8.1 years in the milk group (P = 0.003).

Table 1 summarizes the characteristics of the study population. There were 26 females and 32 males included in the control group, and 24 females and 36 males in the milk group. There were significant differences between the control and milk group for age, height, whole body bone mineral density (WB-BMD), and whole body lean mass. Subjects in the milk group were older (P = 0.003) and, as a consequence, were taller (P = 0.007), slightly heavier (P = 0.061), and had greater lean mass (P = 0.037) than subjects in the control group. Subjects in the milk group had significantly higher whole body BMD than control subjects (P = 0.006). Table 2 shows the breakdown of the two groups by gender. The girls were shorter than the boys in both groups, but this was not significant.

	Control (n = 58)		**Milk Drink (n = 60)**		
Parameter	Mean	Std Dev	Mean	Std Dev	P-Value
Age (y)	7.6	0.99	8.1	0.77	0.0028
Height (cm)	129.9	8.75	133.9	7.11	0.0069
Weight (kg)	29.6	7.58	32.2	7.38	0.0605
Waist (cm)	60.5	8.00	61.4	8.12	0.5358
WB_area	1069.7	107.82	1084.2	80.06	0.4063
WB_BMC (g)	680.3	128.16	717.3	117.52	0.1044
WB_BMD (g/cm^2)	0.630	0.0600	0.660	0.0600	0.0064
LS_BMC (g)	20.4	3.25	20.6	3.40	0.6949
LS_BMD (g/cm^2)	0.670	0.0500	0.680	0.0600	0.1563
WB_fat (g)	9284.1	4099.41	10234.2	4640.58	0.2415
WB_lean (g)	19393.3	4142.80	20928.4	3732.10	0.0365
WB_fatP (%)	30.5	6.08	30.7	6.62	0.8898
z-score	-0.04	0.750	-0.2	0.890	0.3055
BMI	17.3	2.46	17.8	2.65	0.3597
BMI z-score	-0.09	-0.96	0.08	1.04	0.3597

Table 1: *Characteristics of the whole study population.*

(BMI: Body Mass Index; WB-BMD: Total Bone Mineral Density Minus Head; WB-BMC: Total Bone Mineral Content Minus Head; LS-BMD: Lumbar Spine Bone Mineral Density; LS-BMC: Lumbar Spine Bone Mineral Content)

	Control				Milk Drink						
	Female		Male		Female		Male		P-Values		
Parameter	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Gender	Trt	Gender* Trt
Age (y)	7.3	1.04	7.8	0.88	8.0	0.88	8.1	0.68	0.0203	0.0033	0.1805
Height (cm)	127.2	7.37	132.1	9.27	133.8	6.41	134.0	7.63	0.0642	0.0079	0.1166
Weight (kg)	28.0	4.46	30.9	9.25	32.1	6.45	32.3	8.03	0.2326	0.0682	0.3274
Waist (cm)	59.6	5.71	61.2	9.49	61.6	7.79	61.3	8.45	0.6393	0.5530	0.5162
WB Area	1052.8	74.75	1083.4	128.19	1075.8	60.47	1078.7	102.94	0.3534	0.6977	0.4511
WB BMC (g)	650.6	94.93	704.4	146.95	707.0	82.66	724.1	136.64	0.1059	0.1200	0.4233
WB BMD (g/cm^2)	0.6	0.05	0.7	0.06	0.7	0.05	0.7	0.06	0.0531	0.0076	0.3666
LS BMC (g)	20.1	3.19	20.6	3.33	20.4	3.57	20.8	3.33	0.3995	0.7270	0.9532
LS BMD (g/cm^2)	0.7	0.05	0.7	0.05	0.7	0.06	0.7	0.06	0.2176	0.1396	0.9867
WB Fat (g)	9358.7	2509.03	9223.5	5080.8	11355.1	3913.6	9486.9	4980.0	0.2438	0.2178	0.2901
WB Lean	17822.1	2664.81	20669.9	4698.7	19862.6	3104.6	21638.9	3980.8	0.0010	0.0440	0.4502
WB Fat%	32.9	5.24	28.6	6.08	34.5	5.18	28.2	6.32	<.0001	0.6959	0.3872
z-score	0.0	0.69	-0.1	0.81	-0.2	0.75	-0.2	0.99	0.5656	0.3220	0.9935
BMI	17.2	1.95	17.4	2.84	17.8	2.62	17.7	2.70	0.9134	0.3659	0.7958
BMI-ZS	-0.1	0.76	-0.1	1.11	0.1	1.03	0.1	1.06	0.9134	0.3659	0.7958

Table 2: *Characteristics of the groups presented by gender.*

There were no significant differences between the boys and girls from both groups with regards to waist circumference, whole body area, whole body BMC, lumbar spine BMC or BMD, but the whole body BMD was marginally different between the boys and girls, with differences between the groups as well (P = 0.007). The boys had significantly increased lean mass compared to the girls in both groups (P < 0.001), with a significant difference between the groups (greater lean mass in the milk group) as well (P = 0.04). However, the girls in both groups had a high percentage fat compared to the boys (P < 0.001). There were no significant differences between the boys and girls with regards to BMD z-score, BMI or BMI z-score.

Changes in body composition and bone mineral content over one year

DXA was used to determine the whole body headless bone mineral density (WB-BMD) and bone mineral content (WB-BMC). The sites selected for BMD and BMC analysis were total body and lumbar spine (L1-L4). Body composition including the whole body lean mass (WB-Lean), whole body fat mass (WB-fat), and whole body percent body fat (WB-fatP) were also determined from the whole body DXA scan.

Treatment effect over time (boys and girls together in each group)

There are no significant differences between the groups for change in height, weight, waist, WB-fat and lean mass as well as fat percentage. This is an indication that both groups were growing at the same pace and that there was no significant increase in weight or body fat in the milk group relative to the controls. There were no significant changes in BMI z score in the groups overall as well as no significant difference between the groups.

There was a significant effect of treatment over time (trt*time interaction) for WB area (P = 0.046), and a marginally significant effect on WB- BMC (P = 0.051) and BMC z-score (P = 0.093). For whole body area and BMC, the increases between visit 1 and visit 2 were greater

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in the milk group than the controls, after correcting for age at baseline, school, and gender. The BMC z-score tended to decrease in the control group (P = 0.170), but tended to increase in the milk group (P = 0.323).

When height was included as co-variate, the WB-BMC and LS-BMC increased in the milk group while remaining stable in the control group.

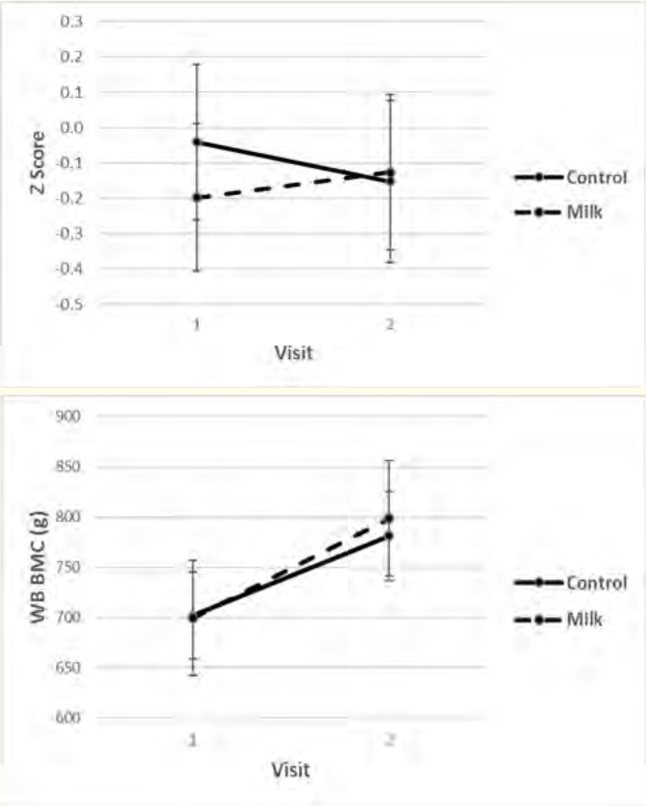
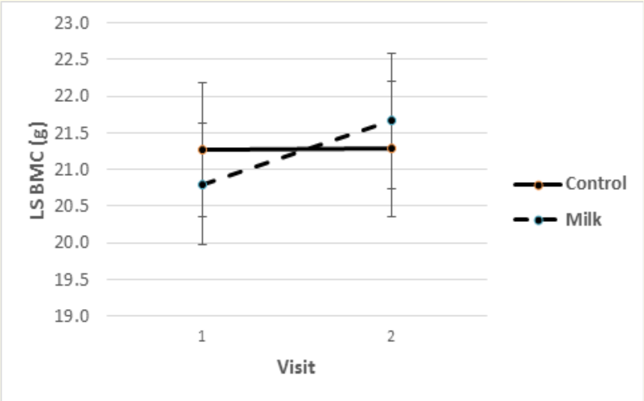


Figure 1: *Change over time for BMC z score (A) and WB-BMC (B) in the control as well as the milk group.*



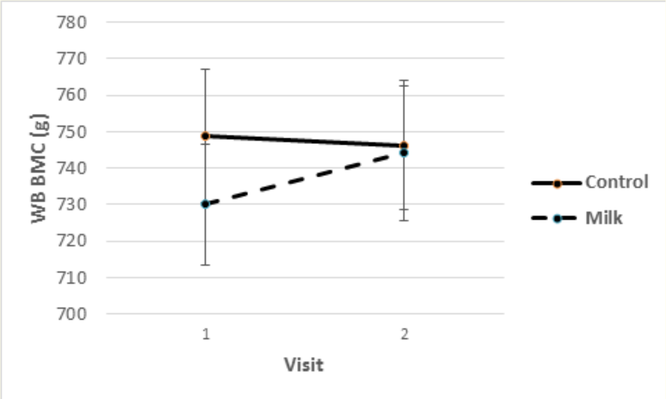
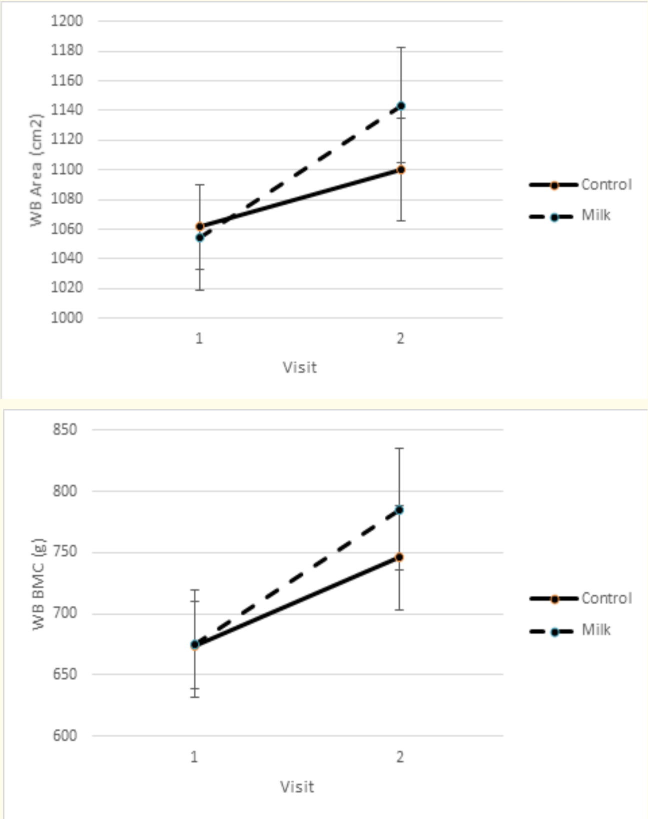


Figure 2: *Change over time for WB-BMC and LS-BMC in the control as well as the milk group with height included as covariate in the model.*

Treatment effect over time by gender

When the data were analysed by gender, all significant effects and trends were in girls. Figure 3 illustrates some of the results. The results show there was a significant effect of treatment over time (trt*time interaction) for WB area (P = 0.004), WB BMC (0.010), and a marginally significant effect on LS BMC (P = 0.087). Lean mass was also affected by a significant interaction (P = 0.044). In all cases, the increases between visit 1 and visit 2 were greater in the milk group than the controls, after correcting for age at baseline and school.



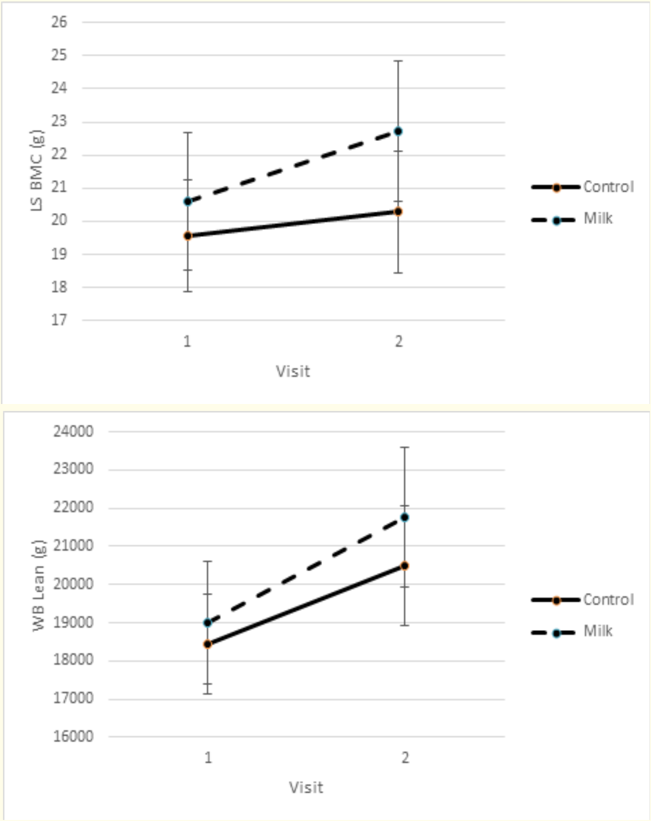


Figure 3: *Changes over time of WB area, WB BMC, LS BMC and WB lean mass (girls only).*

Associations

Differences between Control and Milk groups seem that for the milk group, changes in whole body area and mineral content were in excess of those expected due to changes in body size (height, weight, BMI, and waist circumference). Increase in whole body mineral content was generally higher in the milk group regardless of changes in height (P = 0.026).

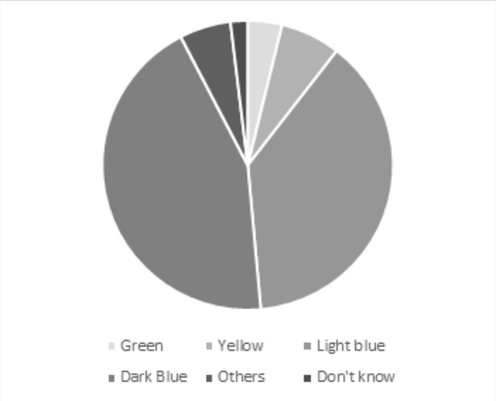
The change in lean mass over time in all children was significantly associated with change in WB-BMC, WB-BMD and change in the z-score for BMC was significantly correlated with change in BMC and BMD as well as the change in lean body mass. Whole body fat mass was significantly associated with whole body BMC (P < 0.001).

Food Frequency Questionnaire

The data from the questionnaire indicated that on weekdays 85% of children in the control group were consuming at least two serves of either milk or milk products compared to 94% of the milk group. At the one year follow up 98% of the milk group were consuming two or more serves of dairy on weekdays versus 85% of the controls.

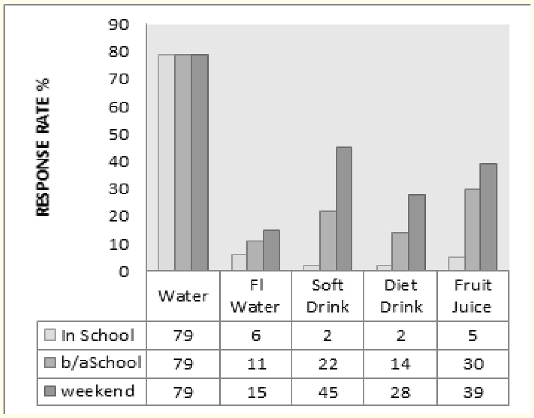
Figure 4 shows the variety of milk types consumed by the children. Most of the children preferred reduced fat (light blue) or full fat (dark blue) milk with less indicating green (skim) or yellow (calcium fortified skim milk) as their milk of choice.

Figure 5 indicates that more soft drinks and fruit juices were consumed over weekends while during the school week water was the main beverage.



Milk type	Drinkers (%)
Green	3.8
Yellow	6.6
Light blue	38
Dark Blue	44
Others	5.7
Don’t know	2

Figure 4: *Types of milk consumed by the whole group of children. Green: Skim Milk; Yellow: Calcium Fortified Skim; Light Blue: Reduced Fat; dark blue: Full Fat.*



	Water	Fl Water	Soft Drink	Diet Drink	Fruit Juice
▢ In School	79	6	2	2	5
▨ b/aSchool	79	11	22	14	30
■ weekend	79	15	45	28	39

Figure 5: *Beverages consumed by the whole group of children at school, after school and over the weekend. (FL water: Flavoured Water).*

When the children were asked about their taste preference for various dairy foods, milk and flavoured milk seem to be the most popular and for children who did not like milk, yogurt seemed to be the most preferred.

Discussion

In tables 1 and 2 the baseline characteristics of the children are summarised. The average height and weight were higher than previously recorded by the New Zealand Ministry of Health in 2006/7 (MoH) [12-14]. The MoH reported an average height of 125 cm for both males and females in the age group 5 - 9 years and an average weight of 28 kg. However, our recorded BMI values are similar to those reported by MoH at an average of 17 for both females and males. The BMI z-scores in table 2 also indicate that our study group of children in general were not obese.

Comparing the milk group versus the control group, results indicate that age, height, whole body BMD, and whole body lean mass was significantly higher in the milk group at baseline. When assessing treatment effects over one year (all children), there were no significant differences between the control group and milk group after one year for change in height, weight, waist circumference, whole body fat, BMI z-score, lean mass as well as fat percentage. This indicated that both groups grew as expected with no significant differential in weight gain. Using treatment by time analysis, whole body area (size of skeleton) and whole body BMC were significantly higher in the milk group with the BMC z-score increasing in the milk group while decreasing in the controls. Interestingly most significant changes were in the girls. Whole body area, BMC, lumbar spine BMD, lean mass had a significant treatment*time interaction and a marginal significant effect on lumbar spine BMC with all changes greater in the milk drinkers.

Consumption of dairy products in childhood and adolescence is known to have a positive effect on bone mineralization in adulthood and can reduce the risk for developing osteoporosis [1,5]. In studies of BMC, osteoporotic women reported less milk and dairy intake when they were children or adolescents compared with non-osteoporotic controls [15-17]. However, it has also been suggested that calcium/dairy intake can have a significant effect on bone mass in young adults. Matkovic., *et al*. [18] stated that bone mass at any age is the result of age and sex, and other genetically determined factors, but that nutrition has a significant effect, and two decades later, a study reported that higher milk intake during adolescence was associated with greater total body spine and radial bone mineral during development of peak bone mass [18,19]. Thus, increasing dairy product intake appears to be a beneficial strategy for improving health and bone health in growing children.

Wiley [20], more recently presented an interesting perspective on cow's milk consumption and human biology; posing the question of whether drinking cow's milk accelerates linear growth and maturation or affects size in adulthood. The results presented were drawn from new analyses of NHANES data collected between 1999 - 2004, and other published studies in the US [20]. Overall, children aged 24 - 59 months with the highest quartile of milk intake (> 2 cups per day), attained a greater height percentile compared with those in the lower quartiles of intake. However, in the age group 5 - 11 years, the height percentiles were not significantly different. The review by Wiley [20] refers to a high quality study done in the 1920's by Leighton and Clark (1929), where children were provided with various amounts of milk or biscuits for 7 months on school days, and significantly more growth was observed in the milk-supplemented groups. In this study, however, the children's energy intake was controlled. In contrast, a study in New Zealand, reported that children who avoided milk were shorter than milk-drinking controls [21]. Data on prepubertal children (5 - 11 years) are therefore more variable compared to data on infants or children aged 24 - 59 months. Some studies support associations between milk and height while others do not show any relationship. In addition, the studies indicating a positive relationship did not control for energy intake. While the re-analyses of the 1999 - 2004 NHANES data indicated that children in the highest quartile of milk intake were the tallest, milk consumption as such had no relationship to height in that age group [20].

Brett., *et al*. [22], examined the milk intakes of healthy children in Montreal, Canada using a food frequency questionnaire. Seventy five children, average age 5 years old, participated. Whole body BMC, BMD and fat % were also measured. The authors concluded that in their study sample almost all of the children reached the recommended two serves of dairy per day and there were no associations between tertiles of milk product intake and BMD or BMC. The authors concluded that in the children who meet the recommended two servings of dairy products per day, milk product intake may not be associated with bone development or body composition. Our data do indicate that the milk drinkers were taller than the controls, but as our trial did not control for energy or dietary intake, our data should be interpreted with caution. However, it should be noted that in addition to increasing calcium availability, milk also provides energy and contributes to macronutrient intake, which may also impact on height and growth.

Numerous studies have shown that a gender- based difference in body composition exists in pre-pubertal and pubertal children [23-25]. In these studies fat mass (FM) and % body fat (BF) were found to be higher among girls than boys and WB lean mass (WB lean) or fat free mass was significantly higher in boys. This current study also showed similar results with girls having a higher % BF and boys having greater WB lean mass (Table 2).

Several factors are believed to play a role in this disparity of fat distribution between genders; hormonal or endocrinal factors near or during puberty can affect the body composition in children. Some studies have found that both WB lean mass and whole body fat mass are positive predictors of bone mineral status [26-8], while others show a positive relation between bone mineral and WB lean mass but an inverse association with FM [28,29]. Bone studies have also shown a gender based effect on bone; in girls FM is considered a better determinant of bone mineral status and in boys the LBM is more strongly related to bone status [30,31]. These effects, however, change after puberty [29]. Gender difference and its effect on the relationship between body composition and bone mass could not be observed in this study due to a relatively small sample size and also no significant difference was found between any of the bone variables based on gender. However, in the total group lean mass was more strongly associated with bone mineral status of the children than fat mass.

The food questionnaire indicated that on weekdays, 85% of the controls consumed at least two serves of milk or milk products per day, compared to between 94 and 98% of the milk drinkers. So the majority of the children met the New Zealand Ministry of Health [12-14] recommendations of 2 - 3 serves per day. The majority of the children consumed whole milk followed by low fat milk (Figure 4).

The frequency of consumption of other beverages was also recorded. Water was the most frequently consumed during the week as well as weekends, with the consumption of soft drinks and fruit juice increasing significantly over weekends. The MoH (2008/2009) reported in their survey of dietary habits of children (n = 647), that water was most commonly consumed with up to 85.1% of children drinking plain water seven or more times per week [13]. The report also states that up to 62.5% of the children drank milk at least once a week. The MoH survey did not include other dairy products so the data from our questionnaire could be directly compared to the outcomes of the survey. Our data however indicate that during the week including weekends, more than 70% of the children consumed more than two serves of dairy per day, which would include milk. The MoH survey reports that about 4% of the children in the survey, drink fizzy drinks or soft drink seven or more times per week. Our results indicate that while very few children drank soft drinks in school, several reported drinking soft drinks or fruit juice before or after school and significantly more over weekends (Figure 5). This may be an issue due to the high sugar content of both fizzy drinks as well as fruit juice which may contribute to the development of obesity in children. However when the children in our trial were asked which drinks were healthy, the majority of the children indicated that firstly water or then milk was considered healthy while soft drinks and flavoured milk were not seen as healthy.

This study had a number of limitations: The number of participants was relatively small; the children's socioeconomic status was not taken into account and the study was uncontrolled and therefore not controlling for energy intake, vitamin D status or physical activity which all could affect bone outcomes.

Conclusion

In conclusion, LBM and WB fat mass significantly predicted children's bone health. Both the control and milk groups increased in height and weight at a similar rate. The changes in LS-BMC, WB- BMC and WB area were greater in the milk group over the year, with the BMC z-score increasing in the milk group but remaining stable in the controls, indicating slower mineralization of growing bones. Milk and dairy intake increased over the year in the milk group which may indicate that the "Milk for Schools" programme as a whole was an effective means of changing children's diets. This observation also provides evidence that a school-based intervention could be used as a means of modifying children's diets.

These are interesting findings, and further work including a larger sample size, being monitored over a longer period of time, and including food questionnaires over time may confirm these findings.

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Conflict of Interest

The authors declare no conflict of interest.

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