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Milk Intake, Height and Body Mass Index in Preschool Children

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Abstract

Objectives—Evaluate links between the volume of milk consumed and weight and height status in children age 4 and 5 years.

Design—We analyzed data from 8950 children followed as part of the Early Childhood Longitudinal Survey–Birth cohort, a nationally-representative cohort of children. We used linear and logistic regression to assess associations of daily servings of milk intake at age 4 years with *z*-scores of BMI, height and weight-for-height at 4 and 5 years, adjusted for sex, race/ethnicity, socioeconomic status and type of milk consumed.

Results—Among children who drank milk at age 4 years, higher milk consumption was associated with higher *z*-scores of BMI, height and weight-for-height at 4 years (all $p<0.05$). This corresponded to differences between children drinking <1 and ≥4 milk servings daily of approximately 1 cm in height and 0.15 kg in weight. By age 5 years only the association with height remained significant ($p<0.001$). At 4 years, children drinking ≥3 servings of milk daily were more likely to be overweight/obese (BMI≥85th percentile) than those drinking 0.5–2 servings of milk daily (adjusted odds ratio 1.16 [95% confidence interval 1.02–1.32] $p=0.02$).

Conclusions—In a cohort of children at age 4 years, the volume of milk consumed was associated with higher weight status and taller stature, while at 5 years, higher milk consumption continued to be associated with taller stature. Given higher odds of overweight/obesity with milk consumption ≥3 servings daily, this study supports current American Academy of Pediatrics recommendations that pre-school children consume 2 milk servings daily.

Keywords

Obesity; growth; height; weight; milk; preschoolers

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INTRODUCTION

Childhood linear growth and weight gain are important markers of nutritional status and overall health[1]. However, the recent epidemic of early childhood obesity[2 3] highlights sequelae of excess weight gain such as hypertension, cardiovascular disease, and type 2 diabetes in adulthood[4 5]. Thus, there is a need to establish effective weight control strategies for preschool-aged children.

One possible intervention is decreasing high-energy beverage consumption, including milk, which contains 83–149 calories per serving[6]. The American Academy of Pediatrics (AAP) and the American Dietetic Association recommend two servings (2 cups or 573 mL) of milk daily for children 2–8 years[7]. However, the basis for these recommendations is unclear. Data linking the quantity of milk consumption to weight status of preschoolers are limited and conflicting. Several studies of beverage consumption in preschoolers and school-aged children reported no relationship between the amount of milk intake and body mass index (BMI) *z*-score[8–11]; three studies reported lower BMI *z*-scores among children with higher milk consumption[12–14] (or less body fat with higher total dairy[15 16]); and another study reported higher BMI increases in children drinking >3 servings of milk daily[17].

Complicating the matter is the potential effect of milk consumption on linear growth[18]. Multiple studies[18–23] (but not all[24 25]) found taller stature in individuals who drank more milk during different periods of childhood, though this has not yet been observed in preschoolers. Following the physiologic nadir of BMI at approximately 4–5 years of age, increases in linear growth are associated with physiological increases in BMI, raising the potential that milk-related increases in BMI could be related to increasing linear growth[26]. Data are lacking regarding the association between milk consumption and weight-for-height, leaving unclear the relationship between milk consumption and unhealthy weight status.

Our goal was to evaluate relationships between the amount of milk consumed and *z*-scores of BMI, height and weight-for-height among a large cohort of 4–5 year-old children. These children were studied as part of the Early Childhood Longitudinal Study, Birth Cohort (ECLS-B), a prospective, representative survey of US children. Our hypotheses were that higher quantities of milk consumed would be associated with higher *z*-scores for BMI and height and a greater increase in BMI *z*-score over time.

METHODS

Data Set

The ECLS-B is a large multi-source, multi-method study sponsored by the National Center for Education Statistics (NCES – US Department of Education) to examine influences on early childhood experiences. The NCES ethics review board approved the study. This nationally-representative sample of children born in 2001 was selected by randomly sampling >14,000 birth certificates, with a final sample of approximately 10,700 completed parent interviews (77% response rate). Parents gave informed consent. We utilized data from the 4-year-old and 5-year-old evaluations where information on milk consumption was gathered, enabling prospective analysis among preschoolers.

Measures

During the 4-year visit parents were interviewed in their home by trained assessors. The primary caregiver (most often the mother) completed a computer-assisted interview. Parents were asked a set of questions regarding the type and frequency of beverage intake, including: "During the past 7 days, how many times did your child drink milk?" Parents were instructed to include all types of milk from a glass, cup or carton, or with cereal. They were instructed that the ½-pint of milk served at school equals one glass (8 ounces, 236 mL). Categories for frequency included no intake during the past week, 1–3 times per week, 4–6 times per week, once daily, twice daily, three times daily and ≥4 times daily. For purposes of reporting prevalence data, these quantities were converted to 0, <1, 1, 2, 3, ≥4 servings daily. In addition, parents were asked if their child usually drinks whole milk, 2%, 1%, skim, soy or other. Parents were similarly asked about the amount of sugar-sweetened beverages (SSB) their child consumed[27].

Direct measurements of weight were obtained by trained researchers using standardized protocols and equipment including a digital scale. Children were dressed in light clothing without shoes. BMI was calculated as weight (kilograms)/(height (meters))^2. Gender-specific percentiles and *z*-scores for BMI, height, and weight-for-height (comparing a particular child's weight to standards for reference children with that exact height) were generated using SAS code from the CDC growth measures. Weight categories were designated normal weight (<85th%), overweight (>85th–95th%) and obese (>95th%).

Parents identified their child's gender and race/ethnicity. Race/ethnicity was grouped into five categories: white, black, Asian, Hispanic and other. NCES calculated socio-economic status (SES) based on family income, maternal education, maternal occupation, paternal education and paternal occupation[28]. Participants were categorized into SES quintiles (lowest SES=1; highest SES=5).

Data analysis

We performed all analyses using SAS software, V9.3 (SAS Institute Inc., Cary, North Carolina, USA), utilizing survey procedures with sampling weights provided by the NCES to account for the complex sampling design. All statistical significance tests were two-sided with significance of α=0.05. Unweighted sample sizes were rounded to the nearest 50 per NCES rules. To better compare associations of volume of milk among milk drinkers, we excluded children who did not drink milk. To assess the longitudinal links, we evaluated the association of milk intake at 4 years on anthropometry outcomes at 5 years. This approach was used previously[27 29] to minimize reverse-causality. Using multivariable linear regression models, we performed both cross-sectional and longitudinal analyses. First we regressed: (i) age 4- and 5-year *z*-scores for BMI, height and weight-for-height on milk consumption categories (<1, 1, 2, 3, ≥4 glasses of milk daily) at 4-years in cross-sectional analysis; and (ii) longitudinal changes in these *z*-scores (e.g. 5-year BMI *z*-score minus 4-year BMI *z*-score) on baseline milk consumption categories. Similarly, we used multivariable logistic regression models to examine the odds of overweight/obese across the milk consumption categories. We also compared the odds of consumption of SSB among non-drinkers of milk compared to drinkers. Regression coefficients, odds ratios (OR) and

95% confidence intervals (CI) are reported in the text and/or tables. All multivariable models were adjusted for sex, race/ethnicity, SES and milk-type[30]. We assessed our regression models for interactions between the potential confounder variables. Using the LSMEANS in SAS, we adjusted for multiple comparisons with a Bonferroni correction.

RESULTS

Demographics

We analyzed data from 10,700 ECLS-B participants. Of these 8950 at the 4-year evaluation and 7000 at the 5-year evaluation had complete data on our variables of interest. Among participants with anthropometric measures, only 12 children were missing data regarding the amount of milk consumed daily at 4 years. Participant characteristics are shown by milk consumption in Table 1. There was a low rate of non-milk consumption (2.6% of boys and 2.1% of girls). Non-milk drinkers appeared to be different from milk drinkers in that as compared to milk drinkers, non-drinkers were more likely to consume ≥1 serving of SSB daily (adjusted odds ratio 1.55, CI 1.06–2.27, $p<0.05$). Among milk-drinking children, the majority drank 2 or 3 servings of milk per day (53%). There was no correlation between the type and the amount of milk consumed (data not shown). There was a high degree of overweight (16.3%) and obesity (16.0%) in this preschool age group. Compared to higher SES quintiles, there was both a higher percentage of children drinking low amounts of milk (<1 serving daily) and a high amount of milk (≥4 servings daily) in lower SES quintiles.

Cross-sectional associations of milk consumption with height and weight at 4 years

Linear regression—On cross-sectional analysis, there was a positive association between the number of servings daily at 4 years and the BMI *z*-score at 4-years; this association persisted following adjustment for potential confounding variables ($p<0.05$, Table 2). A similar but stronger association was seen between the amount of milk consumed and height-for-age *z*-score ($p<0.001$). Because higher body weight status can be associated with advanced maturation (and thus taller stature), we also assessed weight-for-height *z*-scores, and these were also positively associated with milk consumption ($p<0.05$). In each of these analyses we adjusted for sex, race/ethnicity, SES and milk-type, which were all related to our outcomes.

Adjusted means—The regression models described above were used to generate mean *z*-scores of BMI, height and weight-for-height by number of daily milk servings, adjusted for sex, SES, race/ethnicity, and type of milk consumed (Figure 1A–C). At 4 years old, children drinking ≥4 servings of milk daily were significantly taller than those drinking 1 serving daily ($p<0.01$).

Logistic regression—When compared to other milk drinkers, children at age 4 years who drank higher volumes of milk (≥3 servings daily, above the AAP recommendation) had a higher odds of overweight/obesity ($p<0.05$) but not obesity (Table 3).

Longitudinal associations of 4 year milk consumption on height and weight at 5 years

In evaluating for longitudinal relationships between milk consumption at 4 years on anthropometric measures at 5 years using linear regression, only the relationship between milk consumption and height-for-age *z*-score persisted ($p<0.001$)(Table 2). In assessing adjusted mean *z*-scores at 5 years old (Figure 1D–F), children drinking 2, 3, and ≥4 servings were taller than those drinking ≤1 and 1 serving daily ($p<0.05$).

There were no associations of milk consumption with changes in *z*-scores of BMI, height or weight-for-height between 4 and 5 years (data not shown).

DISCUSSION

Milk is a common source of protein and nutrients in childhood[31] but when consumed in excess, has potential for unhealthy weight gain. We evaluated a large, nationally-representative sample of children at age 4 and 5 years for associations between milk consumption and weight and height status and found that even after adjustment for potential confounders, children who drank the highest quantities of milk (≥3 servings daily) at age 4 had higher BMI *z*-scores and had a higher odds of overweight. This is a new finding in this preschool age range and is consistent with the potential risk of high-volume milk consumption on excess weight gain—supporting the AAP recommendation[7] for a more restrained milk consumption of 2 servings daily for children in this age range.

The more surprising finding was that children who drank higher amounts of milk at age 4 were also taller at 4 years and remained so when measured 1 year later. At age 4, this difference between those drinking <1 serving daily and those drinking ≥4 was a *z*-score of 0.2, corresponding to a height difference of approximately 1 cm. While this had not previously been noted in children in this age range, similar findings had been seen in studies of wider age groups[18–22], suggesting that there may be unique properties of milk—or simply an overall increase in caloric intake—that may contribute to increased linear growth. The association of milk with height has raised suspicion in some researchers of elevated risk of future fractures (more common in taller individuals)[18] and potential cancer risks (given the potential for higher levels of growth factors)[19], giving these considerations potential importance for public health.

Several possible mechanisms behind these anthropomorphic findings have been proposed in prior studies of milk consumption. In studies reporting *positive* associations between milk consumption and body weight, heavier weight status has been attributed to the effect of higher milk intake on raising total calorie consumption[9 17]. For example, Berkey et al.[17] found that 9–14 year-old children drinking ≥3 servings of milk daily had greater increases in BMI over time than those drinking 1–2 servings daily; however, these differences were eliminated when adjusted for total caloric intake, suggesting that the additional milk consumption did not reduce other calories in the diet otherwise, contributing to higher weight gain. Conversely, research groups finding *inverse* associations between milk consumption and body weight (predominantly noted in adults) have pointed to the potential for satiating effects of fat and calcium (given tight associations of milk intake with total calcium in childhood[32]) on restraining overall food intake[12 16]. For example, Carruth et

al.[16] evaluated children age 2–3 years and found inverse associations between both dairy consumption and calcium consumption with amount of body fat—supporting associations between insufficient calcium intake and unhealthy weight status in preschoolers.

Overall, our data demonstrated a mild association of increased BMI with increasing milk consumption for 4 year-old children, corresponding to a BMI *z*-score of 0.1 between those drinking ≤1 serving and those drinking ≥4 servings. This is a difference of approximately 0.15 kg for a child at the 50th percentile for height. This small difference suggests that any possible association with excess milk intake on weight status appears to be minor. That this association was no longer significant by the time the children turned 5 years may further underscore the overall mild nature of any potential underlying mechanisms—or suggest that the potential effects of milk consumption on unhealthy weight gain are age-dependent.

Speculation regarding mechanisms behind the associations of milk consumption with height has been more varied. While some researchers have implicated calcium content in milk as a potential factor in height gain[33], other groups have focused more on milk's protein content and potential influence on levels of IGF-1[22]. Holmes et al.[34] reported gradual increases in serum IGF-1 levels by quintiles of milk intake in adults. This observation was further supported by Hoppe et al.[23] in a cross-sectional study of 90 children at age 2 years. They found that milk consumption (and total animal protein overall) was associated with both higher levels of serum IGF-1 and with taller height, suggesting potential effects of animal protein on IGF-1 production. Finally, Wiley[21] analyzed cross-sectional associations of milk consumption and height in childhood, finding a positive association in children age 12–18 years but no such association in children age 5–12 years—suggesting potential age-dependent effects that she speculated to be related to milk's protein content.

Not addressed in previous studies of the association of milk consumption with height was the potential that excessive weight gain could have driven taller stature by accelerating skeletal maturation. This is seen in children with exogenous obesity[35] and is reflected by higher weight-for-height *z*-scores; children who have gained height without added weight gain would be expected to have lower weight-for-height *z*-scores. At age 4 years we noted higher weight-for-height *z*-scores, suggesting that at least some of the additional height at this age may have been due to excess weight gain. However, the positive association between higher milk consumption and weight-for-height *z*-scores was no longer present at age 5, suggesting at a minimum that the association of milk consumption with height had a longer duration over time than its association with added weight.

We found it interesting that the relatively small number of children who did not drink milk were more likely to consume more SSB, which are themselves associated with unhealthy weight gain[27]. While adequate delivery of protein and calcium is possible in the absence of milk consumption, these findings emphasize the need to replace milk with healthy drink options, particularly water. With respect to the type of milk consumed, it was notable that the majority of children (>83%) consumed 2% or whole milk. This is in contrast to recommendations of the AAP, which recommends low-fat milk for children >2 years. However, previously published data from this cohort does not support the consumption of low fat milk as a means of restraining weight gain[30].

In this nationally representative sample of preschoolers, the detailed questions about milk consumption were only assessed at the 4 and 5 year-old waves and thus we followed children for only a year and were not able to evaluate the durability of these associations over a longer time frame. We assessed parent report of milk volume and did not have measures of other dairy products or of total calories consumed—and were thus unable to make further causal inferences regarding these associations. Finally, the potential exists for these findings to be related instead to additional unmeasured confounding factors.

In conclusion, these data from a large cohort of preschool children born throughout the United States demonstrate potential stimulatory effects of milk consumption on weight and height in this age range, with the association of milk consumption with height persisting over time. Given these cross-sectional associations of higher milk consumption with odds of overweight/obesity, these data overall support current AAP recommendations to give children 2 servings of milk daily. Further studies are needed to evaluate mechanisms behind these associations and the role of milk consumption on other markers of childhood nutritional status.

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What is already known on this topic

- Among school-age children (but not preschoolers), the amount of milk consumed has been reported to be associated both with higher and lower BMI-*z*-scores.
- In studies of mostly-older children, milk consumption was associated with taller stature; the relationship of this height with weight status is not known.

What this study adds

- Among 4-year-old children, the amount of milk consumed was positively associated with BMI-*z*-score; children drinking ≥3 milk servings daily were more likely to be overweight/obese.
- The amount of milk consumed at age 4 was positively associated with height-for-age-*z*-scores at both age 4 and 5 years.

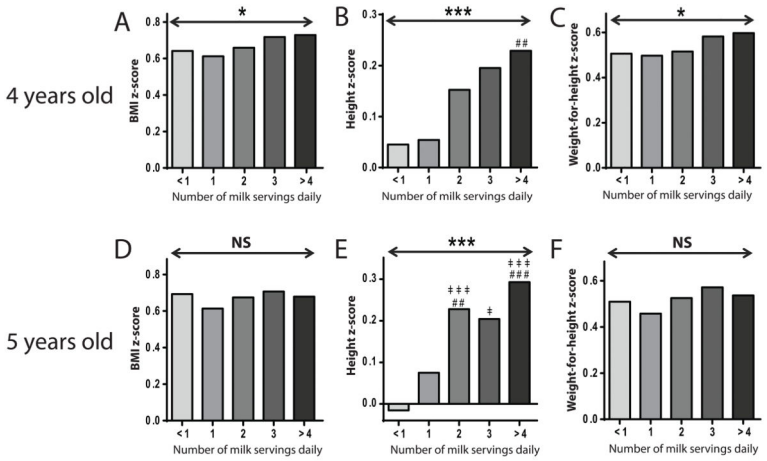

Figure. Milk consumption and anthropomorphic measures

Adjusted mean z-scores for BMI, height and weight-for-height based among milk drinkers based on milk consumption at 4 years of age, as measured at age 4 years (A–C) and 5 years (D–F). All data are adjusted for sex, race/ethnicity, SES and milk type. Arrows indicate linear regression results from the same model, assessing for linear relationships between milk amount and the same z-score outcome. Linear regression: * $p<0.05$; *** $p<0.001$. Adjusted mean values: compared to drinkers of 1 serving daily: ## $p<0.01$, ### $p<0.001$; compared to drinkers of <1 serving: ‡‡ $p<0.01$; ‡‡‡ $p<0.001$.

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Table 1

Descriptive statistics overall and by amount of milk consumed at age 4 years.

	Total number* (weighted % by category)	Daily Milk Amount (weighted %)					
Variable		**0**	**< 1**	**1**	**2**	**3**	**≥ 4**
Gender							
Male	4550	2.6	11.8	15.7	29.3	24.2	16.3
Female	4400	2.1	12.4	16.5	30.6	22.9	15.4
Race/Ethnicity							
White	3900 (43.7)	2.6	10.9	15.2	28.9	24.6	17.8
Black	1350 (15.4)	3.3	19.3	18.7	28.7	16.6	13.4
Hispanic	1750 (19.7)	1.8	9.8	14.4	31.6	26.6	15.9
Asian	900 (10.1)	1.8	8.1	20.3	35.2	23.6	11.0
Other	1000 (11.1)	1.7	15.1	15.2	27.8	24.2	16.0
Socioeconomic Status							
1. High	1950 (23.2)	2.2	9.4	17.2	33.0	25.3	12.9
2. Medium High	1650 (19.8)	2.8	12.2	16.8	30.4	22.5	15.3
3. Medium	1650 (19.9)	2.6	13.2	14.2	29.0	24.1	16.9
4. Medium Low	1600 (19.0)	1.9	13.0	16.2	28.9	22.9	17.0
5. Low	1500 (18.1)	2.4	13.4	15.9	27.4	22.8	18.1
Milk type							
Whole	3650 (43.2)	n/a	13.3	17.8	28.9	24.3	15.9
2%	3350 (40.1)	n/a	11.7	15.8	31.8	23.9	16.9
1%	700 (8.1)	n/a	11.7	14.5	32.1	26.6	15.1
Skim	550 (6.6)	n/a	10.7	13.8	33.0	25.3	17.1
Soy	150 (2.0)	n/a	11.7	19.8	33.3	22.8	12.3
Sugar-sweetened beverage							
<1 serving/day	6300 (70.8)	2.2	12.0	15.8	31.0	23.6	15.4
≥1 serving/day	2600 (29.2)	2.8	12.5	16.8	27.2	23.6	17.1
Weight Status							

	Total number* (weighted % by category)	Daily Milk Amount (weighted %)					
Variable		**0**	**< 1**	**1**	**2**	**3**	**≥ 4**
Normal weight	5750 (67.7)	2.2	11.8	16.3	30.8	23.5	15.3
Overweight	1400 (16.3)	1.7	11.8	15.8	27.7	25.4	17.6
Obese	1350 (16.0)	2.7	13.3	15.8	28.6	22.8	16.7

*Unweighted sample sizes were rounded to the nearest 50 in compliance with NCES rules.

n/a = not applicable

Table 2

Linear regression among milk drinkers of milk consumption at age 4 years on *z*-scores for BMI, height-for-age, and weight-for-age at 4 and 5 yr.

	BMI-*z*-score		**Height-for-age *z*-score (HAZ)**		**Weight-for-height *z*-score (WHZ)**	
Age 4 years	**coefficient (SE)**	***p*-value**	**coefficient (SE)**	***p*-value**	**coefficient (SE)**	***p*-value**
Milk amount (servings daily)	0.034 (0.017)	**0.043**	0.056 (0.014)	**<0.001**	0.033 (0.016)	**0.040**
Sex	−0.095 (0.033)	**0.006**	−0.109 (0.033)	**0.001**	−0.130 (0.031)	**<0.001**
race/ethnicity						
White	−0.116 (0.085)	0.178	−0.140 (0.065)	**0.034**	−0.090 (0.076)	0.239
Black	−0.008 (0.112)	0.942	0.296 (0.068)	**<0.001**	−0.007 (0.106)	0.947
Hispanic	0.063 (0.096)	0.515	0.012 (0.073)	0.869	0.063 (0.087)	0.474
Asian	−0.194 (0.111)	0.0832	−0.190 (0.083)	**0.024**	−0.256 (0.119)	**0.034**
Other	(referent)		(referent)		(referent)	
SES	−0.089 (0.015)	**<0.001**	0.018 (0.013)	0.179	−0.080 (0.015)	**<0.001**
Milk type (increasing fat content)	−0.176 (0.021)	**<0.001**	−0.132 (0.021)	**<0.001**	−0.167	**<0.001**
Age 5 years	coefficient (SE)	*p*-value	coefficient (SE)	*p*-value	coefficient (SE)	*p*-value
Milk amount (servings daily)	0.006 (0.023)	0.789	0.0750 (0.0166)	**<0.001**	0.0224 (0.0189)	0.240
Sex	−0.042 (0.050)	0.4065	−0.019 (0.036)	0.603	−0.103 (0.039)	**0.011**
race/ethnicity						
White	−0.162 (0.087)	0.0651	−0.094 (0.080)	0.242	−0.108 (0.081)	0.185
Black	−0.089 (0.115)	0.4407	0.380 (0.089)	**<0.001**	−0.016 (0.104)	0.880
Hispanic	0.019 (0.097)	0.8432	0.020 (0.086)	0.817	0.094 (0.083)	0.259
Asian	−0.255 (0.111)	**0.0249**	−0.228 (0.092)	0.015	−0.226 (0.104)	**0.032**
Other	(referent)	.	(referent)	.	(referent)	
SES	−0.085 (0.016)	**<0.001**	0.019 (0.017)	0.249	−0.080 (0.014)	**<0.001**
milk type (increasing fat content)	−0.139 (0.034)	**<0.001**	−0.147 (0.030)	**<0.001**	−0.145 (0.027)	**<0.001**

Table 3

Logistic regression of milk consumption at age 4 years (≥ 3 vs. ≤2) on obesity status at 4 and 5 years of age.

	Overweight OR, 95% CI	*p*-value	Obese OR, 95% CI	*p*-value
Age 4 years				
Model 2 (adjusted for sex, race/ethnicity. SES, milk type)	1.159 (1.022,1.315)	**0.0214**	0.994 (0.849, 1.163)	0.9356
Age 5 years				
Model 2 (adjusted for sex, race/ethnicity. SES, milk type)	1.094 (0.917, 1.306)	0.3187	1.047 (0.863, 1.269)	0.6427