The Association Between Changes in Height and Obesity in Chilean Preschool Children: 1996–2004

Sanja Stanojevic, Juliana Kain,† and Ricardo Uauy*†*

Abstract

STANOJEVIC, SANJA, JULIANA KAIN, AND RICARDO UAUY. The association between changes in height and obesity in Chilean preschool children: 1996–2004. *Obesity.* 2007;15:1012–1022.

Objectives: To establish the association between changes in height and prevalence of obesity between 1996 and 2004 in Chilean preschool children.

Research Methods and Procedures: Children registered in the Junta Nacional de Jardines Infantiles (JUNJI) preschool program were routinely measured three times a year and in consecutive years. Two indices [weight-for-height *z*-scores (WHZ) and BMI centiles] were used to define obesity. Height-for-age *z*-scores (HAZ) were used to define stature. Generalized estimating equations were used to describe the relationship between stature and obesity while controlling for repeated measurements in children.

Results: The prevalence of obesity in Chilean preschool children has remained relatively constant over the past 9 years when either index is used. The prevalence of stunted (HAZ $\leq$2) children has decreased, while the proportion of children who are tall (HAZ $>$2) has increased. Using WHZ to define obesity, stunted children do not seem to be at increased risk of obesity when compared with children of normal height. Tall children were strongly protected from obesity when either criterion was used to define obesity.

Discussion: The lack of association between stunting and obesity using WHZ $\geq$2 likely reflects the fact that Chile is in the post-transitional phase of the nutrition transition, and stunting is no longer a risk factor for obesity; however, the associations observed between stunting and BMI suggest that either WHZ or BMI, or both, are inaccurate criteria to define overweight.

Conclusions: There is a unique relationship between stature and obesity in preschool children that is different from that observed in older children in the same population.

Key words: childhood obesity, growth, epidemiology, nutrition transition, stunting

Introduction

The transition in dietary patterns and lifestyles toward high-energy dense foods and sedentary lifestyles, the nutrition transition (1), has led to alarming increases in the prevalence of obesity in developing countries. Chile is a unique example of the nutrition transition because it has undergone changes at a rate much faster than other countries in the region and around the world (2). Today, Chile is considered to be in the post-transitional phase, as exemplified by that fact that malnutrition in children has fallen from 15.5% in 1985 to <1% in 1995, and rates of stunting [low height-for-age *z*-scores (HAZ)][1] have also declined, from 10% in 1985 to 2% in 1998 (3).

Decreases in malnutrition and stunting over the past 30 years are attributed largely to the Programa Nacional de Alimentación Complementaria (3). Designed to promote normal growth and development in children (from conception to 6 years), the program provides food supplements to pregnant or lactating mothers and children under 6 years of age. A separate program, the Junta Nacional de Jardines Infantiles (JUNJI), exists for preschool children (2). In 1998, more than 100,000 children attended JUNJI, of whom 98% were between the ages of 2 and 5. The program covers

Received for review April 25, 2006.
Accepted in final form October 30, 2006.
*Department of Epidemiology and Population Health, London School of Hygiene and Tropical Medicine, London, United Kingdom; and †Institute of Nutrition and Food Technology (INTA), University of Chile, El Libano, Santiago, Chile.
Address correspondence to Sanja Stanojevic, Institute of Child Health, 30 Guilford Street, London, WC1N 1EH, United Kingdom.
E-mail: s.stanojevic@ich.ucl.ac.uk

[1] Nonstandard abbreviations: HAZ, height-for-age *z*-score; JUNJI, Junta Nacional de Jardines Infantiles; WHZ, weight-for-height *z*-scores; SD, standard deviation; GEE, Generalized Estimating Equation; .

~50% of those in need, and food distribution covers 58% to 75% of the children's daily caloric needs.

Despite the improvements in nutrition, adverse effects of dietary changes and sedentary behavior have been observed in preschool children of low socioeconomic status, with the rates of obesity in preschool children nearly doubling, from 6% in 1992 to 10% in 2000 (4). In recent years, the JUNJI program has responded quickly to the increasing rates of obesity by adopting changes to reduce the caloric content of food (i.e., reduced sugar and saturated fat, provision of skimmed milk and additional fruits and vegetables) and increase physical activity (5).

Overweight and obese children pose significant health challenges not only because they have reduced health and fitness (6), but because they often feel socially isolated and have problems adjusting and interacting with peers (7). In childhood, obesity has been found to be associated with increased blood pressure, diabetes, respiratory diseases, and orthopedic problems (7). Most importantly, longitudinal studies indicate that overweight children are at significant risk of remaining overweight as adults (7–9).

Obesity in transitional countries is further complicated by the fact that many individuals are stunted as a result of chronic undernutrition in early life (3). Stunting is caused by prolonged undernutrition during gestation or early childhood (3). Several studies have shown important metabolic changes related to stunting and suggest a tendency toward energy conservation and accumulation of body fat (10,11). The proposed mechanism for obesity among stunted individuals suggests that low-energy intake during growth promotes a higher ratio of cortisol to insulin and lower levels of insulin-like growth factor 1 (12). These hormonal changes lead to low muscle gain and lower linear growth characteristic of malnutrition (12). High cortisol levels are associated with centralization of body fat and could explain the excess abdominal adiposity seen in stunted individuals (13). Furthermore, low levels of insulin-like growth factor 1 may impair lipolysis, the hydrolysis of fat (13,14). Therefore, stunted children have long-term hormonal adaptations that likely affect enzyme and hormone functions, which may further impair fat oxidation, especially when their diet changes to one high in fat (13,15). At present, there is no evidence that shows that stunted children differ with respect to energy intake or expenditure in comparison to normal children (13); therefore, based on these mechanisms and evidence, stunted children are expected to be at higher risk for obesity in countries where undernutrition and obesity coexist.

There is also evidence to suggest that a relationship between obesity and excess height exists. A study of 5- to 18-year-old children in the United States found that, in children <12 years of age, the prevalence of obesity was significantly greater among tall children (16). In Chilean school-age children (6 years of age), there is a J-shaped relationship between stature and obesity, where tall children are at greatest risk for obesity (17). The relationship between stature and obesity in preschool children is not known and warrants further investigation.

This study will examine the effects of secular changes in height from 1996 to 2004 on the prevalence of obesity in Chilean preschool children over that period. It is hypothesized that both stunted and tall children will be at increased risk of obesity and that the relative risk of obesity will increase over time as the nutrition transition progresses.

Research Methods and Procedures

Children registered with the JUNJI preschool program in the metropolitan region of Santiago, Chile, were routinely measured and weighed three times a year, in March, August, and November, between 1996 and 2004. Children registered in the program were from low- and middle-income families and, therefore, are not representative of all preschool children in Chile. Teachers were instructed on how to measure weight and height and how to collect general demographic information. Following a standard protocol, weight was recorded to the nearest 0.1 kg and height to the nearest 0.1 cm using a stadiometer. Children were measured with light clothes and without shoes. The number of children measured each month over the 9-year study period ranged from 19,082 to 29,217. In 2004, there were ~127,000 children registered in JUNJI (nationwide); therefore, the sample in this study represents roughly 20% of all children enrolled in the program.

In 1992, the Chilean Ministry adopted the National Center for Health Statistics/World Health Organization 1977 reference (18) and weight-for-height *z*-scores (WHZ) as the official criteria to evaluate the nutritional status of preschool children in terms of both undernutrition and overnutrition. The NUTSTAT program within EPI Info 2000 (Centers for Disease Control and Prevention) was used to evaluate the nutritional status of children using the National Center for Health Statistics/World Health Organization 1977/1985 reference curves for age, sex, height, and weight. Children were classified as stunted (defined as the failure to reach linear growth potential as a result of sub-optimal health and/or nutritional status) if their HAZ was <-2 standard deviations (SDs) and tall if their HAZ was >2 SD. Children with WHZ ≥ 2 SD were considered obese, and children with a *z*-score <2 but >1 were considered overweight. Analysis was repeated using BMI percentile $\geq 95\%$ (Centers for Disease Control and Prevention 2000) (19) for comparison with an alternative criterion to define obesity.

Children were excluded from analysis if they were less than 2 or more than 5 years of age at the beginning of the school year in March (~6% to 10%) or if their gender, date of birth, or date of measurement was not recorded. Children with HAZ and weight-for-age values outside $\pm$ 3.5 SD were also excluded (~2%), as those values were considered

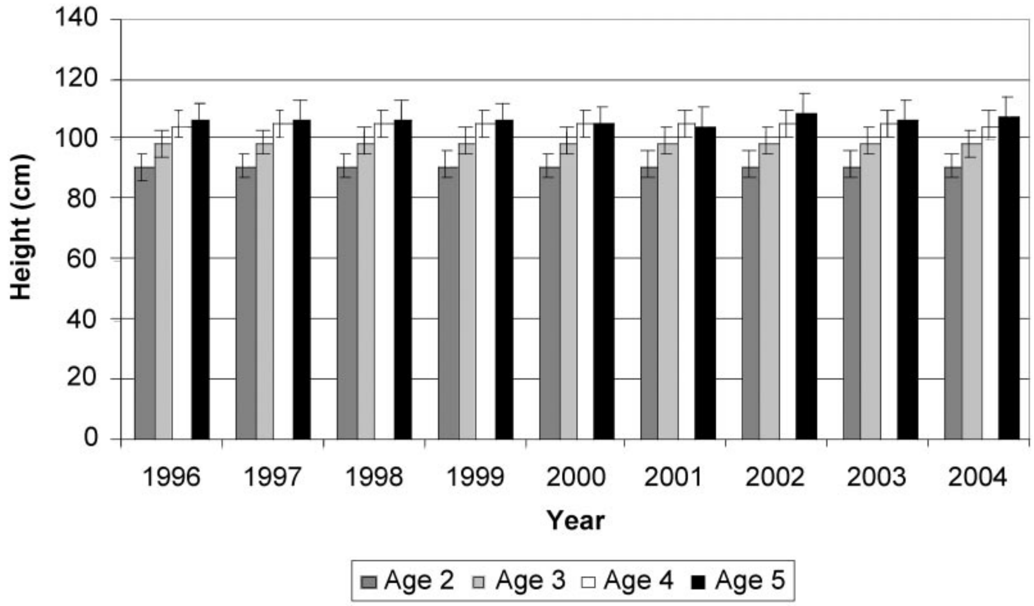

Figure 1: Average height by age of preschool children in Chile, measured at the beginning of the school year in March.

potential measurement or data entry errors. In total, ~7% of children were excluded, with no more than 13% excluded in any 1 month. After exclusion criteria were applied, the number of children included for analysis ranged from 17,553 to 26,308 at each measurement point.

After anthropometric indices were calculated, data were transferred into STATA 8.2 (StataCorp LP., College Station, TX) for further analysis. The association between height and obesity was assessed by dividing children into six categories by HAZ: <-2 SD, "stunted"; -2 SD to -1 SD, "mildly stunted"; -1 SD to median, "normal"; median to 1 SD, "normal"; 1 SD to 2 SD, "normal-tall"; and >2 SD, "tall." To account for the fact that individual children were repeatedly measured, a Generalized Estimating Equation (GEE) model was used to conduct time series analysis within each year and over the study period. The odds of obesity (WHZ $\geq$2 SD or BMI $\geq$95th percentile) in stunted and tall children was calculated relative to children of normal height (HAZ, -1 to 1) and children in the reference risk category using the GEE model. The reference is the HAZ category with the lowest prevalence of obesity, which in this population was observed in the -1 to -2 HAZ category. A multivariate GEE model was used to describe the longitudinal trends in initial HAZ and WHZ on changes in weight and final WHZ at discharge from the program.

Results

Approximately equal numbers of male and female children were measured each month in all years, although there were consistently more males (52%) than females (48%). On average, children were measured five times (range, 1 to 13) and attended the JUNJI program for 2 years (range, 1 to 4). The majority of children enrolled in the JUNJI program were either 3 or 4 years of age at the beginning of the school year in March (mean $\pm$ SD age, 43 $\pm$ 9.04 months).

Visually, height increased slightly over the study period, rising only slightly in the 2-year-old age group, from 90.7 cm in 1996 to 91.1 cm in 2004, and in the 5-year-old age group, from 106.4 cm to 108.0 cm (Figure 1). The proportion of stunted children (HAZ <-2 SD) declined in both boys (2.5% in 1996 to 1.8% in 2004) and girls (2.0% to 1.7%) over the study period, although the decline was more noticeable in boys (Figure 2A). In contrast, the proportion of tall girls rose from 2.3% in 1996 to 2.9% in 2004 and in boys from 1.6% to 2.1% (Figure 2B).

Overall, the rate of obese and overweight children did not change dramatically over the 9 years (Table 1). The prevalence of obesity increased by $<$1%, whereas the prevalence of overweight children remained at 22.7%. When BMI centile $\geq$95% was used to define obese children, the prevalence of obesity also remained stable (Table 1). In all years, the prevalence of obesity was greater in girls than in boys (sex-specific data not shown).

The prevalence of obesity (WHZ $\geq$2 according to HAZ category) is shown in Figure 3. Both tall and stunted children had a greater prevalence of obesity as compared with children in the reference category and lower prevalence compared with children of normal height.

Considering that individual children were measured repeatedly each year, univariate GEE analysis found that stunting was not a significant risk factor for obesity (WHZ $\geq$2) in this population when compared with children of

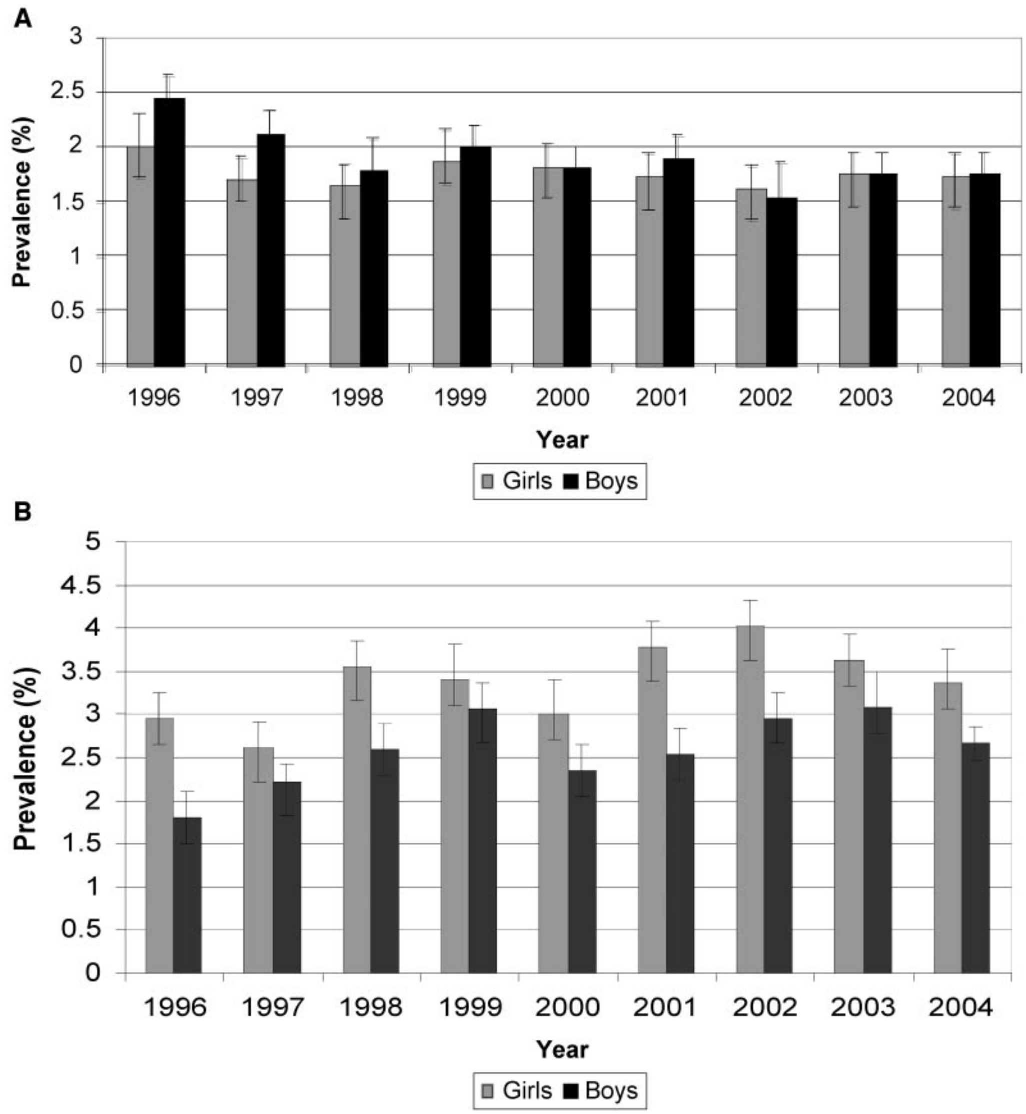

Figure 2: Cross-sectional trends (1996–2004) of the proportion of (A) stunted children (HAZ <-2 SD) and (B) tall children (HAZ >2 SD) measured at the beginning of the school year in March.

normal height (Table 2A). In some years, there was a protective effect of stunting, while in other years stunted children were at increased risk of obesity. Conversely, stunting was a risk factor for obesity when BMI ≥95th percentile was used (Table 2A).

Tall children had substantially lower odds of obesity (reduction ranged from 35% to 45%) as compared with children of normal height when either obesity criterion was used (Table 2B). These results are supported by moderate to very strong statistical evidence, especially when BMI ≥95th percentile was used.

When the risk of obesity in stunted children was compared with children in the reference risk category (Table 3A), stunted children had increased odds of obesity (range, 5% to 59%) when WHZ was used and much greater odds (range, 26% to 83%) when BMI centiles were used.

Tall children also had moderately increased odds of obesity (WHZ) compared with children in the reference category (Table 3B); however, there was very weak evidence to support this finding in most years. The opposite was seen when BMI was used, as tall children were found to be significantly protected against obesity (range, 14% to 37% reduction) in all years.

Longitudinal analysis of obesity (WHZ ≥2) and height, after adjusting for potential confounders (age and sex), found that children who were initially obese were 20 times more likely to be obese at discharge (Table 4). There was also evidence that children who were initially stunted were at increased risk of obesity compared with children in the reference category. Children who were initially tall were more than five times more likely to be obese (WHZ ≥2) when they left the program.

Table 1. Prevalence of overweight and obese preschool children

Year	% Obese (WHZ ≥2)	% Overweight (1< WHZ <2)	% Obese (BMI ≥95%)
1996	8.44	22.71	15.97
1997	8.73	22.87	16.12
1998	9.07	22.59	16.24
1999	8.75	22.83	15.76
2000	9.27	23.64	16.97
2001	9.51	23.20	17.03
2002	8.95	22.76	16.11
2003	9.90	23.37	16.35
2004	9.01	22.74	16.53

WHZ, weight-for-height *z*-score.

Discussion

Between 1996 and 2004, the prevalence of obesity in Chilean preschool children remained stable; despite this, the prevalence was alarmingly high. This study presents two possible relationships between stunting and obesity, depending on which height group (normal or reference) was used as the reference category, as well as which criterion was used to define obesity. When BMI ≥95th percentile was used to define obesity, stunting remained a significant risk for obesity, whereas when WHZ ≥2 was used to define obesity, stunting did not seem to be associated with obesity. Recent evidence suggests that, as the prevalence of stunting decreases in a population, stunting becomes a less significant risk factor for obesity (3,20); and in populations of normal height, obesity in children is associated with increased stature, most likely secondary to enhanced bone age and maturation (20). The null association between obesity and stunting using WHZ in this study may reflect the changes in prevalence of obesity and stunting and suggests that the prevalence of stunting is sufficiently low to not affect obesity rates. On the other hand, the strong association between stunting and obesity when BMI was used suggests that the complex relationship between stunting and obesity still exists. As there is no gold standard for defining obesity in children, the fact that different conclusions are drawn when different criteria are used to definite obesity highlights the need for standardized reference curves and cut-off points.

On a population basis, high WHZ can be considered an adequate indicator of obesity because the majority of individuals with high WHZ are obese (21); however, the cut-off point is arbitrary as it fails to distinguish between fat mass and body fat (21–23) and has not been validated against clinical outcomes. Although WHZ has been found to be significantly correlated with adiposity in adults, in children WHZ is less correlated with adiposity or fatness and, therefore, limiting (23).

Alternatively, BMI is now more frequently used in both clinical and research settings and has been accepted as a valid instrument for identifying obese children (24). However, BMI has low sensitivity to screen obese individuals (25), and its correlation with adiposity is highly variable

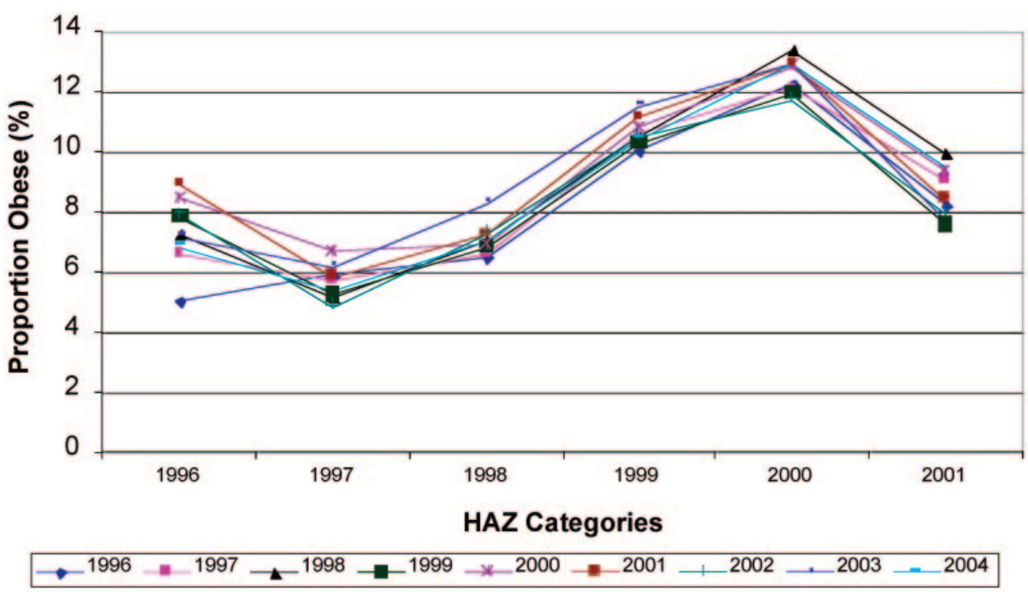

Figure 3: Trends in the prevalence of obesity (WHZ) in preschool children based on height-for-age categories between 1996 and 2004.

Table 2A. The odds of obesity as defined by two criteria in children who are stunted compared to children of normal height

		WHZ ≥2				BMI ≥95th percentile			
		Percentage of obese children		Odds of obesity in stunted children		Percentage of obese children		Odds of obesity in stunted children	
Year	N	Normal*	Stunted	OR (95% CI)	*p* value	Normal*	Stunted	OR (95% CI)	*p* value
March 1996	13893	8.23	5.06			15.69	17.47		
August 1996	15184	10.70	5.57	0.83 (0.63 to 1.10)	0.192	18.45	19.27	1.41 (1.18 to 1.69)	<0.001
November 1996	16066	10.09	5.78			16.62	16.44		
March 1997	14191	8.32	7.36			15.50	21.07		
August 1997	14861	11.88	7.02	1.09 (0.84 to 1.41)	0.523	20.39	20.82	1.58 (1.32 to 1.90)	<0.001
November 1997	16048	10.81	6.25			17.61	13.28		
March 1998	13860	8.94	8.42			16.34	16.31		
August 1998	14440	11.17	7.59	0.75 (0.58–0.96)	0.021	19.36	17.79	1.51 (1.23 to 1.84)	<0.001
November 1998	16415	9.60	8.16			16.06	16.46		
March 1999	15038	8.61	7.58			15.77	18.83		
August 1999	14161	10.98	5.49	1.16 (0.98 to 1.50)	0.254	19.24	20.88	1.75 (1.46 to 2.10)	<0.001
November 1999	16780	10.23	7.42			16.74	19.44		
March 2000	15307	8.67	6.41			16.20	22.31		
August 2000	16571	11.94	11.81	1.25 (1.01 to 1.56)	0.045	20.60	25.93	2.02 (1.71 to 2.38)	<0.001
November 2000	16811	10.88	9.00			17.60	24.09		
March 2001	15221	9.24	6.58			16.79	22.53		
August 2001	15744	11.00	9.81	1.34 (1.06 to 1.70)	0.014	18.93	24.80	1.93 (1.63 to 2.31)	<0.001
November 2001	17081	10.11	10.08			16.60	20.16		
March 2002	15847	9.11	7.26			15.99	25.14		
August 2002	16062	10.83	7.33	1.23 (0.96 to 1.58)	0.104	18.66	24.05	2.27 (1.90 to 2.70)	<0.001
November 2002	17830	9.73	6.28			16.56	18.09		
March 2003	17086	9.12	7.73			16.80	20.84		
August 2003	17830	9.73	6.28	0.83 (0.65 to 1.06)	0.127	16.56	18.09	1.47 (1.25 to 1.73)	<0.001
November 2003	12741	9.53	6.15			15.93	18.12		
March 2004	17707	8.87	6.65			16.48	23.62		
August 2004	18872	10.30	5.89	1.19 (0.93 to 1.53)	0.167	18.44	20.63	1.90 (1.59 to 2.27)	<0.001
November 2004	14985	9.77	6.53			16.42	18.75		

WHZ, weight-for-height *z*-score; OR, odds ratio; CI, confidence interval.
* HAZ >-1 and <1 standard deviation.

Table 2B. The odds of obesity as defined by two criteria in children who are tall compared to children of normal height

		WHZ ≥2				BMI ≥95th percentile			
		Percentage of obese children		Odds of obesity in tall children		Percentage of obese children		Odds of obesity in tall children	
Year	N	Normal*	Tall	OR (95% CI)	*p* value	Normal*	Tall	OR (95% CI)	*p* value
March 1996	13914	8.23	7.24			15.69	11.18		
August 1996	15125	10.70	8.82	0.65 (0.49 to 0.87)	0.004	18.45	15.93	0.61 (0.49 to 0.75)	<0.001
November 1996	16072	10.09	6.80			16.62	11.84		
March 1997	14861	8.32	9.76			15.50	14.84		
August 1997	15267	11.88	10.34	0.75 (0.58 to 0.96)	0.026	20.39	15.76	0.67 (0.55 to 0.82)	<0.001
November 1997	16129	10.81	9.03			17.61	14.62		
March 1998	13860	8.94	8.42			16.34	10.44		
August 1998	14440	11.17	7.59	0.75 (0.58 to 0.96)	0.021	19.36	12.87	0.59 (0.50 to 0.73)	<0.001
November 1998	16415	9.60	8.16			16.06	12.23		
March 1999	15312	8.61	6.59			15.77	10.83		
August 1999	14344	10.98	9.51	0.66 (0.52 to 0.83)	<0.001	19.24	14.99	0.57 (0.47 to 0.68)	<0.001
November 1999	16998	10.23	6.24			16.74	10.84		
March 2000	15488	8.67	9.11			16.20	12.96		
August 2000	16736	11.94	9.72	0.72 (0.57 to 0.90)	0.004	20.60	13.07	0.58 (0.48 to 0.70)	<0.001
November 2000	16951	10.88	7.44			17.60	12.52		
March 2001	15507	9.24	7.93			16.79	11.31		
August 2001	16078	11.00	7.70	0.57 (0.44 to 0.72)	<0.001	18.93	11.98	0.57 (0.42 to 0.61)	<0.001
November 2001	17464	10.11	7.37			16.60	11.71		
March 2002	16270	9.11	6.66			15.99	10.63		
August 2002	16412	10.83	8.97	0.55 (0.44 to 0.70)	<0.001	18.66	13.31	0.50 (0.42 to 0.60)	<0.001
November 2002	18219	9.73	5.97			16.56	10.07		
March 2003	17477	9.12	7.70			16.80	10.76		
August 2003	18219	9.73	5.97	0.61 (0.50 to 0.75)	<0.001	16.56	10.17	0.50 (0.42 to 0.59)	<0.001
November 2003	12841	9.53	6.37			15.93	10.27		
March 2004	18022	8.87	8.79			16.48	12.12		
August 2004	19095	10.30	7.45	0.66 (0.52 to 0.84)	0.001	18.44	12.61	0.59 (0.49 to 0.69)	<0.001
November 2004	15174	9.77	6.65			16.42	12.57		

WHZ, weight-for-height *z*-score; OR, odds ratio; CI, confidence interval.
* HAZ >−1 and <1 standard deviation.

Table 3A. The odds of obesity as defined by two criteria in children who are stunted compared to children in the reference category of height

		WHZ ≥2				BMI ≥95th percentile			
		Percentage of obese children		Odds of obesity in stunted children		Percentage of obese children		Odds of obesity in stunted children	
Year	N	Reference*	Stunted	OR (95% CI)	*p* value	Reference*	Stunted	OR (95% CI)	*p* value
March 1996	3067	5.81	5.06			14.55	17.47		
August 1996	3380	6.59	5.57	1.05 (0.84 to 1.31)	0.650	17.51	19.27	1.42 (1.21 to 1.65)	<0.001
November 1996	3377	6.56	5.78			15.51	16.44		
March 1997	2973	5.62	7.36			14.35	21.07		
August 1997	3288	7.76	7.02	1.27 (1.02 to 1.58)	0.028	18.43	20.82	1.45 (1.25 to 1.68)	<0.001
November 1997	3190	6.41	6.25			15.29	13.28		
March 1998	2642	5.11	8.42			15.06	16.31		
August 1998	2838	6.08	7.59	1.28 (1.01 to 1.61)	0.036	16.86	17.79	1.26 (1.08 to 1.46)	<0.001
November 1998	3116	5.91	8.16			13.51	16.46		
March 1999	2797	4.77	7.58			13.65	18.83		
August 1999	2718	6.58	5.49	1.33 (1.06 to 1.69)	0.016	17.08	20.88	1.65 (1.42 to 1.93)	<0.001
November 1999	3149	5.77	7.42			14.14	19.44		
March 2000	2838	6.41	6.41			15.44	22.31		
August 2000	3134	7.92	11.81	1.49 (1.22 to 1.81)	<0.001	18.76	25.93	1.83 (1.59 to 2.12)	<0.001
November 2000	3246	7.87	9.00			17.11	24.09		
March 2001	2933	5.91	6.58			15.45	22.53		
August 2001	2848	6.41	9.81	1.59 (1.27 to 1.98)	<0.001	17.57	24.80	1.73 (1.49 to 2.01)	<0.001
November 2001	2992	5.81	10.08			15.14	20.16		
March 2002	2735	4.92	7.26			15.10	25.14		
August 2002	2865	5.35	7.33	1.45 (1.15 to 1.85)	0.002	16.68	24.05	1.80 (1.54 to 2.10)	<0.001
November 2002	3260	5.59	6.28			15.34	18.09		
March 2003	3118	5.69	7.73			15.16	20.84		
August 2003	3260	5.59	6.28	1.31 (1.03 to 1.69)	0.029	15.34	18.09	1.46 (1.24 to 1.72)	<0.001
November 2003	2325	4.76	6.15			13.05	18.12		
March 2004	3459	5.46	6.65			15.42	23.62		
August 2004	3969	5.53	5.89	1.32 (1.04 to 1.68)	0.022	15.24	20.63	1.68 (1.45 to 1.94)	<0.001
November 2004	2843	5.38	6.53			15.13	18.75		

WHZ, weight-for-height *z*-score; OR, odds ratio; CI, confidence interval.
* HAZ >-2 and <-1 standard deviation.

Table 3B. The odds of obesity as defined by two criteria in children who are tall compared to children in the reference category of height

		WHZ ≥2				BMI ≥95th percentile			
		Percentage of obese children		Odds of obesity in tall children		Percentage of obese children		Odds of obesity in tall children	
Year	N	Reference*	Tall	OR (95% CI)	*p* value	Reference*	Tall	OR (95% CI)	*p* value
March 1996	3088	5.81	7.24			14.55	11.18		
August 1996	3321	6.59	8.82	1.19 (0.93 to 1.53)	0.167	17.51	15.93	0.74 (0.60 to 0.89)	0.002
November 1996	3383	6.56	6.80			15.51	11.84		
March 1997	3071	5.62	9.76			14.35	14.84		
August 1997	3281	7.76	10.34	1.42 (1.13 to 1.76)	0.003	18.43	15.76	0.86 (0.72 to 1.03)	0.099
November 1997	3271	6.41	9.03			15.29	14.62		
March 1998	2905	5.11	8.42			15.06	10.44		
August 1998	2941	6.08	7.59	1.42 (1.13 to 1.79)	0.003	16.86	12.87	0.71 (0.59 to 0.86)	<0.001
November 1998	3322	5.91	8.16			13.51	12.23		
March 1999	3071	4.77	6.59			13.65	10.83		
August 1999	2901	6.58	9.51	1.25 (0.99 to 1.57)	0.056	17.08	14.99	0.73 (0.61 to 0.87)	0.001
November 1999	3367	5.77	6.24			14.14	10.84		
March 2000	3019	6.41	9.11			15.44	12.96		
August 2000	3299	7.92	9.72	1.09 (0.88 to 1.35)	0.444	18.76	13.07	0.65 (0.55 to 0.78)	<0.001
November 2000	3386	7.87	7.44			17.11	12.52		
March 2001	3219	5.91	7.93			15.45	11.31		
August 2001	3182	6.41	7.70	1.20 (0.98 to 1.49)	0.083	17.57	11.98	0.65 (0.55 to 0.77)	<0.001
November 2001	3375	5.81	7.37			15.14	11.71		
March 2002	3158	4.92	6.66			15.10	10.63		
August 2002	3215	5.35	8.97	1.22 (0.98 to 1.52)	0.069	16.68	13.31	0.63 (0.53 to 0.74)	<0.001
November 2002	3649	5.59	5.97			15.34	10.07		
March 2003	3509	5.69	7.70			15.16	10.76		
August 2003	3649	5.59	5.97	1.20 (0.97 to 1.48)	0.089	15.34	10.17	0.65 (0.55 to 0.77)	<0.001
November 2003	2425	4.76	6.37			13.05	10.27		
March 2004	3774	5.46	8.79			15.42	12.12		
August 2004	3919	5.53	7.45	1.35 (1.09 to 1.67)	0.006	15.24	12.61	0.71 (0.60 to 0.84)	<0.001
November 2004	3032	5.38	6.65			15.13	12.57		

WHZ, weight-for-height *z*-score; OR, odds ratio; CI, confidence interval.
* HAZ >−2 and <−1 standard deviation.

Table 4. Multivariate mixed model analysis examining the odds of obesity at exit from the program compared to initial anthropometric factors

	Crude analysis			Adjusted analysis		
	OR	**95% CI**	***p* value**	**OR**	**95% CI**	***p* value**
Obese at entry	20.00	16.96–23.48	<0.001	19.89	16.84–23.49	<0.001
Stunted at entry	0.71	0.28–1.80	0.467	0.63	0.23–1.73	0.373
Tall at entry	3.60	2.15–6.03	<0.001	5.22	3.00–9.15	<0.001

OR, odds ratio; CI, confidence interval.

(range, 0.4 to 0.9) (26). Like WHZ, BMI cannot distinguish between fat free and fat mass (26), and it tends to overclassify tall individuals as obese (25). BMI better reflects excess body fat in children over 5 years of age (26); therefore, its appropriateness for use in this population is questionable.

It is thought that increasing hormonal and skeletal maturation leads to faster linear growth in childhood and early puberty; therefore, tall children should be at increased risk for obesity (27). This study failed to find excess height to be a significant risk factor for obesity, as was observed in older children in the same population (17). The difference observed between preschool and school-age children in Chile might be explained by the timing of the adiposity rebound. The adiposity rebound occurs right after the point of minimal BMI, and its timing may be critical for the development of obesity (28). Energy excess in childhood may induce an early adiposity rebound that is coupled to linear growth acceleration (28). This may explain the association between tallness and obesity observed in this study for children with height-for-age greater than the median, as presented in Figure 3. The consequences of stunting may also be suppressed until puberty when the greatest changes in stature occur (29). The height of children with HAZ >2 may be due predominantly to genetics and, thus, is not associated with obesity. The lack of association of tallness and obesity in this group with HAZ >2 could also be an artifact, since very few children (<2% of the population) had HAZ >2. Also, the reference curves may be excessively tolerant with respect to WHZ in tall children and are underestimating the true prevalence of overweight and obese children (30).

Interestingly, children who were initially tall for their age were more than five times more likely to be obese when they left the program, suggesting that HAZ in the early years of life is a strong predictor of obesity. This finding also coincides with what we would expect metabolically in tall children and with previously published findings (16,28).

One of the main strengths of this study is its large sample size and, thus, power to detect a difference. The use of standardized protocols reduces measurement errors and, therefore, fewer children were excluded as a result of error. The prospective nature of the data collection made it possible to avoid recall and information bias.

A major limitation of the anthropometric indices used in this study is the use of the World Health Organization/Centers for Disease Control and Prevention reference population, which is based on a population of bottle-fed infants in the United States and is more than 30 years old (30). The results also lack generalizability, as they are representative of low- and middle-income children in Santiago.

The exclusion criteria in this study are routinely used in similar studies (31,32); however, approximately 2% of children had WHZ >3.5 SD and were, therefore, excluded from the analysis. While measurements outside this range are typically errors, it is possible that children who were grossly overweight were excluded unnecessarily.

There are still very few published studies that have examined the longitudinal relationship between stature and obesity and even fewer that have examined the relationship between tallness and obesity in children. Further investigations into the effects of stature on obesity in different age groups and at different stages of the nutrition transition are necessary before a conclusive relationship is established.

Acknowledgments

The authors thank the Junta Nacional de Jardines Infantiles (JUNJI) preschool program in Chile for kindly providing the data for this study and Nutritionist Juanita Rojas who acted as liaison between JUNJI and Institute of Nutrition and Food Technology (INTA). There was no funding/outside support for this study.

References

1. **Popkin BM.** The nutrition transition and obesity in the developing world. *J Nutr*. 2001;131(suppl):871–3.
2. **Uauy R, Albala C, Kain J.** Obesity trends in Latin America: transiting from under- to overweight. *J Nutr*. 2001;131(suppl):893–9.
3. **Kain J, Burrows R, Uauy R.** Obesity trends in Chilean children and adolescents: basic determinants. In: Chen C, ed.

Obesity in Childhood and Adolescence. Philadelphia, PA: Lippincott Williams & Wilkins; 2002, pp. 45–61.
4. **Olivares S, Kain J, Lera L, Pizarro F, Vio F, Moron C.** Nutritional status, food consumption and physical activity among Chilean school children: a descriptive study. *Eur J Clin Nutr*. 2004;58:1278–85.
5. **Velasquez M, Salazar G, Vio F, Hernandez J, Rojas J.** Nutritional status and body composition in Chilean preschool children attending day care centers. *Food Nutr Bull*. 2002;23: 250–3.
6. **Fisberg M, Baur L, Chen W, et al.** Obesity in children and adolescents: Working Group report of the second World Congress of Pediatric Gastroenterology, Hepatology, and Nutrition. *J Pediatr Gastroenterol Nutr*. 2004;39(Suppl 2):678–87.
7. **de Onis M, Blossner M.** Prevalence and trends of overweight among preschool children in developing countries. *Am J Clin Nutr*. 2000;72:1032–9.
8. **Serdula MK, Ivery D, Coates RJ, Freedman DS, Williamson DF, Byers T.** Do obese children become obese adults? A review of the literature. *Prev Med*. 1993;22:167–77.
9. **Whitaker RC, Wright JA, Pepe MS, Seidel KD, Dietz WH.** Predicting obesity in young adulthood from childhood and parental obesity. *N Engl J Med*. 1997;337:869–73.
10. **Martins PA, Hoffman DJ, Fernandes MT, et al.** Stunted children gain less lean body mass and more fat mass than their non-stunted counterparts: a prospective study. *Br J Nutr*. 2004;92:819–25.
11. **Sawaya AL, Roberts S.** Stunting and future risk of obesity: principal physiological mechanisms. *Cad Saude Publica*. 2003;19(Suppl 1):21–8.
12. **Waterlow J.** *Protein-Energy Malnutrition*. London, UK: Edward Arnold; 1992.
13. **Sawaya AL, Grillo LP, Verreschi I, da Silva AC, Roberts SB.** Mild stunting is associated with higher susceptibility to the effects of high fat diets: studies in a shantytown population in Sao Paulo, Brazil. *J Nutr*. 1998;128(Suppl 2): 415–20.
14. **Hoffman DJ, Sawaya AL, Verreschi I, Tucker KL, Roberts SB.** Why are nutritionally stunted children at increased risk of obesity? Studies of metabolic rate and fat oxidation in shantytown children from Sao Paulo, Brazil. *Am J Clin Nutr*. 2000;72:702–7.
15. **Popkin BM, Richards MK, Monteiro CA.** Stunting is associated with overweight in children in four nations that are undergoing the nutrition transition. *J Nutr*. 1996;126:3009–16.
16. **Freedman D, Thornton JC, Mei Z, et al.** Height and adiposity in children. *Obes Res*. 2004;12:846–53.
17. **Kain J, Uauy R, Lera L, Taibo M, Albala C.** Trends in height and BMI of 6 year-old children during the nutrition transition in Chile. *Obes Res*. 2005;13:2178–86.
18. **Waterlow JC, Buzina R, Keller W, Lane JM, Nichaman MZ, Tanner JM.** The presentation and use of height and weight data for comparing the nutritional status of groups of children under the age of 10 years. *Bull World Health Organ*. 1977;54:489–98.
19. **Centers for Disease Control/National Center for Health Statistics.** *CDC Growth Charts*. Atlanta, GA: Centers for Disease Control/NCHS; 2000.
20. **Uauy R, Kain J.** The epidemiological transition: need to incorporate obesity prevention into nutrition programmes. *Public Health Nutr*. 2002;5:223–9.
21. **World Health Organization.** *Physical Status*: *The Use and Interpretation of Anthropometry*. Geneva, Switzerland: World Health Organization; 1995.
22. **Power C, Lake JK, Cole TJ.** Measurement and long-term health risks of child and adolescent fatness. *Int J Obes Relat Metab Disord*. 1997;21:507–26.
23. **Martorell R, Kettel Khan L, Hughes ML, Grummer-Strawn LM.** Overweight and obesity in preschool children from developing countries. *Int J Obes Relat Metab Disord*. 2000;24:959–67.
24. **Dennison BA, Erb TA, Jenkins PL.** Television viewing and television in bedroom associated with overweight risk among low-income preschool children. *Pediatrics*. 2002;109:1028–35.
25. **Wang Y.** Epidemiology of childhood obesity—methodological aspects and guidelines: what is new? *Int J Obes Relat Metab Disord*. 2004;28(Suppl 3):21–8.
26. **Kain J, Uauy R, Vio F, Albala C.** Trends in overweight and obesity prevalence in Chilean children: comparison of three definitions. *Eur J Clin Nutr*. 2002;56:200–4.
27. **Leonard M, Shults J, Wilson BA, Tershakovec AM, Zemel BS.** Obesity during childhood and adolescence augments bone mass and bone dimensions. *Am J Clin Nutr*. 2004;80:514–23.
28. **Whitaker RC, Pepe MS, Wright JA, Seidel KD, Dietz WH.** Early adiposity rebound and the risk of adult obesity. *Pediatrics*. 1998;101:e5.
29. **He Q, Karlberg J.** BMI in childhood and its association with height gain, timing of puberty, and final height. *Pediatr Res*. 2001;49:244–51.
30. **de Onis M.** The use of anthropometry in the prevention of childhood overweight and obesity. *Int J Obes Relat Metab Disord*. 2004;28(Suppl 3):81–5.
31. **Thompson D, Jago R, Baranowski T, et al.** Covariability in diet and physical activity in African-American girls. *Obes Res*. 2004;12(suppl):46–54.
32. **Yanovski JA.** Pediatric obesity. *Rev Endocr Metab Disord*. 2001;2:371–83.