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ASSOCIATION BETWEEN BODY COMPOSITION, SOMATOTYPE AND SOCIOECONOMIC STATUS IN CHILEAN CHILDREN AND ADOLESCENTS AT DIFFERENT SCHOOL LEVELS

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Summary. This study examined the association between body composition, somatotype and socioeconomic status (SES) in Chilean children and adolescents by sex and school level (grade). The cross-sectional study was conducted on 1168 schoolchildren aged 6–18 years (572 males) from Valparaíso, Chile. Body composition, as assessed by percentage body fat (BF%) and somatotype, was evaluated using Ellis equations and the Heath–Carter method, respectively. The socioeconomic status of respondents was assessed using the ESOMAR survey. Obesity was defined as BF% ≥25 for boys and ≥30 for girls; 'high endomorph' somatotype was defined as a somatotype endomorph component (EC) of at least 5.5. Logistic regression analysis was used to assess the relationship between high adiposity and SES, potential confounding factors and school level. In females, the results indicated that the groups with lower SES had higher EC. At the 1st (youngest) school level (1–4th grades), males exhibited similar trends in their BF% and EC. High adiposity was associated with the female sex (BF%: OR = 3.39; 95% CI 2.60, 4.41; high EC: OR = 2.31; 95% CI 1.80, 2.98). In addition, low SES increased the risk of high adiposity compared with high SES (BF%: OR = 2.25; 95% CI 1.40, 3.61; high EC: OR = 2.19; 95% CI 1.37, 3.47). An association was observed between increased adiposity and lower SES, mainly in females, which indicates that females with low SES might be at greater risk of obesity.

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Introduction

Childhood obesity is considered a global epidemic and public health crisis in developed and developing countries (Lobstein *et al*., 2004) because of its high prevalence and association with risk factors for cardiovascular diseases, articulatory problems, sleeping disorders and insulin resistance, among others (Ebbeling *et al*., 2002; Guh *et al*., 2009). In Chile, many changes in socioeconomic conditions, including economic growth, urbanization and globalization, have modified Chilean lifestyle over recent decades. This has brought about an increase in the consumption of high energy density foods (i.e. rich in fat and sugar), together with a significant rise in sedentary lifestyles among all age groups (Albala *et al*., 2001; Kain *et al*., 2002).

According to a nutritional map generated by the National Board for School Assistance and Scholarships (JUNAEB), the obesity prevalence in Chile in 2014 was 22.3% in girls and 28.3% in boys in the first grade of school, and 11.0% in girls and 13.6% in boys in the ninth grade (JUNAEB, 2014). However, studies of somatotype – defined as the morphological shape of a subject at a given moment – in the region of Valparaiso have demonstrated a disadvantage in the use of body mass index (BMI) as a measure of adiposity, in that it evaluates the relationship between mass and height without taking adipose and muscle tissue make-up into account. Notably, the somatotype of the Chilean teenage (15- to 18-year-old) population has shifted towards a predominantly endomorph somatotype (related to relative adiposity), particularly in girls, whereas its mesomorph component (associated with muscularity) has decreased (Lizana *et al*., 2012). The increase in high relative adiposity in school-aged children is a major public health concern because the health consequences persist into adulthood, contributing to increases in chronic non-transferable diseases (NCDs) (Kendzor *et al*., 2012).

Many studies have demonstrated associations between socioeconomic status (SES) in childhood and a higher risk of developing NCDs (Shrewsbury & Wardle, 2008). The mechanisms underlying this association have been studied in great detail, and many articles investigating the role of obesity have been published over the last decade (see, e.g., Wang & Zhang, 2006; Liberona *et al*., 2011; Wronka, 2014). Shrewsbury and Wardle found a predominantly inverse association between SES and adiposity in children in 45 research projects conducted between 1990 and 2005 (Shrewsbury & Wardle, 2008). The goal of this study was to compare the body composition and somatotype of schoolchildren by SES and school stage in the region of Valparaiso, Chile.

Methods

A total of 1168 children and adolescents between the ages of 6 and 18 years (572 males) from educational institutions in the Valparaíso, Viña del Mar and Concón regions of Valparaíso, Chile, were enrolled in the study. The sample was divided into three school levels: Level 1, 1st–4th grades (6–9 years); Level 2, 5th–8th grades (10–13 years); and Level 3, 9th–12th grades (14–17 years) (see Table 1). All of the children were evaluated between the years 2011 and 2012.

Anthropometry measurements

Body fat percentage. Body mass index was estimated as weight (kg) divided by the square of height (m^2). Body fat percentage (BF%) was derived from the anthropometric equations described by Ellis (1997) and Ellis *et al.* (1997), which were specifically tailored to Hispanic children and adolescents by sex: Hispanic boys, BF (kg) = $0.591\times$ weight (kg) $-1.82\times$ age (years) $+ 3.36$; Hispanic girls, BF (kg) = $0.667\times$ weight (kg) $-0.217\times$ height (cm) $+ 15.5$.

Obesity was defined as BF% ≥25 in boys and ≥30 in girls (Williams *et al.*, 1992).

Somatotype. To calculate Heath and Carter's anthropometric somatotype three numerical ratings representing the endomorph, mesomorph and ectomorph components were calculated (Carter & Heath, 1990). The ratings were calculated using ten anthropometric measurements. Height was measured using a SECA 217 stadiometer (0.1 cm precision); mass was measured using a SECA 813 scale (0.1 kg precision); four skinfolds (triceps, subscapular, supraspinal and medial calf) were measured using a Slim Guide calliper; two bone breadths (the biepicondyles of the humerus and femur) were evaluated with a small Campbell 10 anthropometer; and two perimeters (flexed arm in maximum tension and leg) were measured with a Lufkin flexible steel tape-measure. Anthropometric measurements were taken in triplicate by the first author for the right side of the body with the median value being used as the criterion.

Mean somatotype and the three somatotype components (i.e. endomorph, mesomorph and ectomorph components) were used in the analysis. For a comparison between groups, the Somatotype Dispersion Mean ($\text{SDM}=\sqrt[3]{((X_2-X_1)^2+(Y_2-Y_1)^2)}$) was applied, which corresponds to a two-dimensional dispersion measurement of somatotype.

Carter and Heath's thirteen categories were used to classify somatotype (see Carter & Heath, 1990). A graphic representation of the somatotype was made by means of a somatochart, which is a projection of the three-dimensional somatochart over a two-dimensional plan. The values of the X and Y co-ordinates were calculated, where:

$$X = \text{ectomorphy} - \text{endomorphy};$$

and

$$Y = 2\times \text{mesomorphy} - (\text{ectomorphy} + \text{endomorphy})].$$

'High endomorph' was defined as an endomorph component (EC) of ≥5.5 (Carter & Heath, 1990).

Socioeconomic status

The European Society for Opinion and Marketing Research (ESOMAR) survey, adapted to Chile, was used to determine socioeconomic status (ADIMARK, 2016). The survey was based on the household main provider's occupation and educational level, and was delivered and applied to parents or guardians. The survey assigned one of six SES strata to a family: A = very high SES, B = high SES, C_a = medium–high SES, C_b = medium SES, D = medium–low SES; and E = low SES. If the main provider was inactive in terms of work (i.e. retired, unemployed, inexistent or simply not classifiable), a set of six goods was used: automobile, computer, microwave, video camera, hot shower system and cable TV service. For this study, the following categories were grouped: A + B, corresponding to the very high and high SES levels; C_a, medium–high SES; C_b, medium SES; and D + E, medium–low SES; and low SES.

Statistical analysis

The descriptive statistics of the sample were calculated as means, standard deviations, frequencies and percentages. The normality of the data distribution was evaluated separately using the Shapiro–Wilk test. Significant differences in sample characteristics by school level and sex were evaluated based on a Mann–Whitney *U* test (non-parametric). For categorical variables, the chi-squared test was used. A variance analysis (one-way ANOVA) and Bonferroni's test were applied for comparison of the continuous variables. The SDM was used for somatotype comparison among groups, in which a value equal to or greater than 2 corresponds to a statistically significant difference ($p < 0.05$). The relation between adiposity and SES was assessed using logistic regression models. Obesity (as indicated by BF%) and a high EC were considered as the dependent variables in the models. In two models, the primary explanatory variable was high or low SES versus medium SES. The models were adjusted for potential confounding factors, including sex, school level and height. For the remaining analyses a significance of $p < 0.05$ was used. The data were analysed in the STATA 12.0 statistical package.

Ethical considerations

The subjects were informed of the procedures via a written consent form as part of the preliminary screening. All of the procedures were in line with the ethical policies established in the Declaration of Helsinki (World Medical Association, 2008). In addition, the protocol was approved by the Ethics Committee of the Pontificia Universidad Católica de Valparaíso, Chile.

Results

Table 1 presents the general characteristics of the sample: age, height, weight, BMI, BF% and somatotype components (endomorphy, mesomorphy and ectomorphy) by sex and school level. Comparing these variables by sex at each school level, significant differences were found in the mesomorph component: this was higher for males than females at all school levels, and decreased over time in parallel with moderate skeletal muscle development. The height of males was significantly greater than that of females at Level 3 ($p < 0.01$). The EC was higher in Level 3 females compared with those at Levels 2 and 1, and a high relative adiposity (>5.5) was maintained in this component. The ectomorph component was higher in males and increased over time but did not change in volume or relative linearity by height for either sex; the values did not exceed 2.5 for this component. In the last school level, which included the adolescents in the sample, significant differences by sex were found in all variables except age and BMI. In addition, the highest prevalence of obesity was reported in females at Level 3 (over 80%).

When the children were classified by SES and somatotype (Tables 2 and 3), in the male sample a higher percentage of individuals were sorted into the mesomorph–endomorph category (39.8%), independent of SES. However, separating

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Table 1. Characteristics of schoolchildren (n = 1168) by sex and school level, 2011–2012, Valparaíso, Chile

	Level 1 (1st–4th grade)				Level 2 (5th–8th grade)				Level 3 (9th–12th grade)			
	Males (n = 175)		Females (n = 163)		Males (n 225)		Females (n = 162)		Males (n 172)		Females (n = 271)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age (years)	7.80	1.24	7.80	1.27	11.60	1.29	11.62	1.49	15.73	1.27	15.86	1.30
Height (m)	1.30	0.09	1.29	0.81	1.51	0.95	1.49	0.08	1.70*	0.69	1.58	0.06
Weight (kg)	33.32	8.74	32.86	8.30	48.82	12.18	47.20	11.10	67.51*	12.79	59.23	10.88
BMI (kg/m^2)	19.51	3.39	19.38	3.27	21.12	3.95	20.96	3.56	23.22	3.93	23.56	3.99
%BF[a]	25.40*	7.59	28.22	5.93	21.00*	8.38	30.61	6.15	20.57*	6.72	34.98	5.01
Obesity[b]												
Non-obese, n (%)	79 (45.14)		98 (60.12)*		146 (64.89)		66 (40.74)*		124 (72.09)		44 (16.24)*	
Obese, n (%)	96 (54.86)		65 (39.88)		79 (35.11)		96 (59.26)		48 (27.91)		227 (83.76)	
Somatotype												
Endomorph[c]	5.05	2.72	5.39	2.18	5.44	2.71	5.78	2.06	4.66*	2.31	6.40	1.93
Low–moderate, n (%)	100 (57.14)		83 (50.92)		122 (54.22)		70 (43.21)*		117 (68.02)		96 (35.42)*	
High[c], n (%)	75 (42.86)		80 (49.08)		103 (45.78)		92 (56.79)		55 (31.98)		175 (64.58)	
Mesomorph	5.09*	1.29	4.71	1.12	4.77*	1.24	4.13	1.19	4.67*	1,45	4.19	1.38
Ectomorph	1.51	1.18	1.49	1.13	2.20	1.53	2.06	1.39	2.38*	1.45	1.64	1.21

[a]Pecentage body fat (BF%) was estimated using Ellis equations for Hispanic children.
[b]Definition of obesity: BF% ≥25 for boys; ≥30 girls.
[c]High endomorph was ≥5.5.
*$p < 0.05$ using Mann–Whitney U-test for continuous variables and chi-squared test for categorical variables.

Table 2. Distribution (*n*, %) of thirteen somatotype categories among male schoolchildren (n = 572) by education level and socioeconomic status[a], 2011–2012, Valparaíso, Chile

	Somatotype	A + B	C_a	C^b	D + E	Total
Total						
	Balanced endomorph	0.0 (0)	0.8 (1)	1.4 (3)	3.1 (6)	1.8 (10)
	Mesomorphic endomorph	**44.7 (17)**	**37.8 (48)**	**42.1 (91)**	**37.7 (72)**	**39.8 (227)**
	Mesomorph–endomorph	7.9 (3)	7.1 (9)	8.8 (19)	6.3 (12)	7.5 (43)
	Endomorphic mesomorph	10.5 (4)	17.3 (22)	19.4 (42)	16.8 (32)	17.5 (100)
	Balanced mesomorph	7.9 (3)	5.5 (7)	4.2 (9)	8.9 (17)	6.3 (36)
	Ectomorphic mesomorph	7.9 (3)	11.0 (14)	6.0 (13)	11.5 (22)	9.1 (52)
	Mesomorph–ectomorph	2.6 (1)	0.8 (1)	3.2 (7)	1.6 (3)	2.1 (12)
	Mesomorphic ectomorph	13.2 (5)	11.0 (14)	8.8 (19)	5.8 (11)	8.6 (49)
	Blanced ectomorph	2.6 (1)	0.8 (1)	1.4 (3)	1.6 (3)	1.4 (8)
	Endomorphic ectomorph	0.0 (0)	3.1 (4)	2.3 (5)	2.1 (4)	2.3 (13)
	Endomorph-ectomorph	0.0 (0)	1.6 (2)	0.0 (0)	0.0 (0)	0.4 (2)
	Ectomorphic endomorph	0.0 (0)	1.6 (2)	0.5 (1)	1.0 (2)	0.9 (5)
	Central	2.6 (1)	1.6 (2)	1.9 (4)	3.7 (7)	2.5 (14)
Level 1 (1st–4th grade)						
	Balanced endomorph	0.0 (0)	0.0 (0)	0.0 (0)	2.9 (2)	1.1 (2)
	Mesomorphic endomorph	20.0 (2)	**48.9 (21)**	**42.6 (23)**	**27.9 (19)**	**37.1 (65)**
	Mesomorph-endomorph	10.0 (1)	11.6 (5)	9.3 (5)	8.8 (6)	9.7 (17)
	Endomorphic mesomorph	20.0 (2)	23.3 (10)	25.9 (14)	25.0 (17)	24.6 (43)
	Balanced mesomorph	10.0 (1)	7.0 (3)	5.6 (3)	11.8 (8)	8.6 (15)
	Ectomorphic mesomorph	**30.0 (3)**	4.7 (2)	3.7 (2)	14.7 (10)	9.7 (17)
	Mesomorph-ectomorph	10.0 (1)	0.0 (0)	3.7 (2)	0.0 (0)	1.7 (3)
	Mesomorphic ectomorph	0.0 (0)	2.3 (1)	5.6 (3)	1.5 (1)	2.9 (5)
	Blanced ectomorph	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
	Endomorphic ectomorph	0.0 (0)	0.0 (0)	1.9 (1)	2.9 (2)	1.7 (3)
	Endomorph-ectomorph	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
	Ectomorphic endomorph	0.0 (0)	2.3 (1)	0.0 (0)	2.9 (2)	1.7 (3)
	Central	0.0 (0)	0.0 (0)	1.9 (1)	1.4 (1)	1.1 (2)
Level 2 (5th–8th grade)						
	Balanced endomorph	0.0 (0)	0.0 (0)	0.0 (0)	4.5 (4)	1.8 (4)
	Mesomorphic endomorph	**61.1 (11)**	**43.8 (14)**	**45.3 (39)**	**47.2 (42)**	**47.1 (106)**
	Mesomorph-endomorph	11.1 (2)	3.1 (1)	9.3 (8)	5.6 (5)	7.1 (16)
	Endomorphic mesomorph	11.1 (2)	6.3 (2)	11.6 (10)	10.1 (9)	10.2 (23)
	Balanced mesomorph	0.0 (0)	6.3 (2)	1.2 (1)	5.6 (5)	3.4 (8)
	Ectomorphic mesomorph	0.0 (0)	12.5 (4)	9.3 (8)	9.0 (8)	8.9 (20)
	Mesomorph-ectomorph	0.0 (0)	3.1 (1)	4.7 (4)	2.2 (2)	3.1 (7)
	Mesomorphic ectomorph	11.1 (2)	15.6 (5)	14.0 (12)	7.9 (7)	11.6 (26)
	Blanced ectomorph	0.0 (0)	0.0 (0)	2.3 (2)	1.1 (1)	1.3 (3)
	Endomorphic ectomorph	0.0 (0)	3.1 (1)	1.2 (1)	2.2 (2)	1.8 (4)
	Endomorph-ectomorph	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
	Ectomorphic endomorph	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
	Central	5.6 (1)	6.3 (2)	1.2 (1)	4.5 (4)	3.6 (8)

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Table 2. *Continued*

Somatotype	A + B	C_a	C^b	D + E	Total
Level 3 (9th–12th grade)					
Balanced endomorph	0.0 (0)	1.9 (1)	3.9 (3)	0.0 (0)	2.0 (4)
Mesomorphic endomorph	**40.0 (4)**	**25.0 (13)**	**38.2 (29)**	**16.1 (10)**	**28.0 (56)**
Mesomorph-endomorph	0.0 (0)	5.8 (3)	7.9 (6)	3.2 (2)	5.5 (11)
Endomorphic mesomorph	0.0 (0)	19.2 (10)	23.7 (18)	54.8 (34)	31.0 (62)
Balanced mesomorph	20.0 (2)	3.8 (2)	6.6 (5)	6.5 (4)	6.5 (13)
Ectomorphic mesomorph	0.0 (0)	15.4 (8)	3.9 (3)	6.5 (4)	7.5 (15)
Mesomorph-ectomorph	0.0 (0)	0.0 (0)	1.3 (1)	1.6 (1)	1.0 (2)
Mesomorphic ectomorph	30.0 (3)	15.4 (8)	5.3 (4)	4.8 (3)	9.0 (18)
Blanced ectomorph	10.0 (1)	1.9 (1)	1.3 (1)	3.2 (2)	2.5 (5)
Endomorphic ectomorph	0.0 (0)	5.8 (3)	3.9 (3)	0.0 (0)	3.0 (6)
Endomorph-ectomorph	0.0 (0)	3.8 (2)	0.0 (0)	0.0 (0)	1.0 (2)
Ectomorphic endomorph	0.0 (0)	1.9 (1)	1.3 (1)	0.0 (0)	1.0 (2)
Central	0.0 (0)	0.0 (0)	2.6 (2)	3.2 (2)	2.0 (4)

[a]A + B, very high and high SES; C_a, medium–high SES; C_b, medium SES; D + E, medium–low SES; and low SES.
High prevalence by group is shown in bold.

by school levels revealed that individuals were aggregated into the mesomorph–endomorph category, with the exception of Level 1, where SES A + B individuals were distributed mainly in the ectomorph–mesomorph category (30%).

In the total female sample, a majority of the individuals were sorted into the mesomorph–endomorph category (64.8%), but as SES decreased, the individuals disaggregated by school levels.

Somatotypes showed significant differences in their EC (Table 4), with individuals of lower SES ranking higher compared with those of higher SES. The predominant relative adiposity transitioned from moderate to high for individuals of medium, medium–low and low SES levels. The mesomorph component values were moderate for all levels. However, the ectomorph component declined as SES decreased.

Sex-specific analysis revealed significant differences in the female group. By component, endomorphy increased as SES decreased, and in this group, adiposity shifted from moderate to high at the medium–high income level. This contrasts with males, for whom high adiposity values were maintained. In a similar manner, the ectomorph component decreased with lower SES. Comparing somatotype as a whole (SDM), it was observed that differences in the total sample could be attributed to the female gender, whereas extreme SES resulted in significant differences ($A + B \neq C_b$; $A + B \neq D + E$; $C_a \neq D + E$).

Table 5 shows body composition and somatotype by school level, sex and SES. The male sample registered significant differences in BMI, BF% and EC at school Level 1, where SES C_a was significantly higher than D + E. In contrast, in the ectomorph component of Level 1, SES C_a was lower than D + E. Levels 2 and 3 in males showed significant differences in somatotype as a whole, whereas in Level 2, A + B differed from C_a and C_a differed from D + E. In Level 3, C_a differed from C_b. Females in Level 1

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Table 3. Distribution (n, %) of thirteen somatotype categories among female schoolchildren (n = 596) by education level and socioeconomic status, Valparaíso, Chile, 2011–2012

	Somatotype	A + B	C_a	C_b	D + E	Total
Total						
	Balanced endomorph	1.6 (1)	4.1 (6)	3.1 (6)	1.5 (3)	2.7 (16)
	Mesomorphic endomorph	**42.6 (26)**	**55.1 (80)**	**66.9 (129)**	**72.8 (152)**	**64.9 (387)**
	Mesomorph-–endomorph	4.9 (3)	9.0 (13)	5.7 (11)	4.6 (9)	6.0 (36)
	Endomorphic mesomorph	19.7 (12)	7.6 (11)	9.3 (18)	2.5 (5)	7.7 (46)
	Balanced mesomorph	4.9 (3)	1.3 (2)	1.6 (3)	0.5 (1)	1.5 (9)
	Ectomorphic mesomorph	4.9 (3)	2.1 (3)	0.5 (1)	0.0 (0)	1.2 (7)
	Mesomorph-ectomorph	6.6 (4)	2.8 (4)	1.6 (3)	0.5 (1)	2.0 (12)
	Mesomorphic ectomorph	0.0 (0)	1.4 (2)	1.0 (2)	0.0 (0)	0.7 (4)
	Blanced ectomorph	4.9 (3)	1.4 (2)	0.0 (0)	1.0 (2)	1.2 (7)
	Endomorphic ectomorph	3.3 (2)	3.4 (5)	3.6 (7)	2.5 (5)	3.2 (19)
	Endomorph-ectomorph	0.0 (0)	4.1 (6)	0.5 (1)	0.5 (1)	1.3 (8)
	Ectomorphic endomorph	4.9 (3)	5.5 (8)	4.7 (9)	6.6 (13)	5.5 (33)
	Central	1.6(1)	2.1 (3)	1.6 (3)	2.5 (5)	2.0 (12)
Level 1 (1st–4th grade)						
	Balanced endomorph	0.0 (0)	2.4 (1)	0.0 (0)	2.2 (1)	1.2 (2)
	Mesomorphic endomorph	**29.2 (7)**	**41.5 (17)**	**58.5 (31)**	**75.6 (34)**	**54.6 (89)**
	Mesomorph-endomorph	8.3 (2)	14.6 (6)	13.2 (7)	4.4 (2)	10.4 (17)
	Endomorphic mesomorph	25.0 (6)	19.5 (8)	17.0 (9)	6.7 (3)	16.0 (26)
	Balanced mesomorph	12.5 (3)	2.4 (1)	5.7 (3)	2.2 (1)	4.9 (8)
	Ectomorphic mesomorph	12.5 (3)	4.9 (2)	1.9 (1)	0.0 (0)	3.7 (6)
	Mesomorph-–ectomorph	4.2 (1)	7.3 (3)	1.9 (1)	2.2 (1)	3.7 (6)
	Mesomorphic ectomorph	0.0 (0)	2.4 (1)	1.9 (1)	0.0 (0)	1.2 (2)
	Blanced ectomorph	8.3 (2)	2.4 (1)	0.0 (0)	2.2 (1)	2.5 (4)
	Endomorphic ectomorph	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
	Endomorph-ectomorph	0.0 (0)	0.0 (0)	0.0 (0)	2.2 (1)	0.6 (1)
	Ectomorphic endomorph	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
	Central	0.0 (0)	2.4 (1)	0.0 (0)	2.2 (1)	1.2 (2)
Level 2 (5th–8th grade)						
	Balanced endomorph	0.0 (0)	4.3 (2)	2.2 (1)	2.0 (1)	2.5 (4)
	Mesomorphic endomorph	**55.5 (11)**	**51.1 (24)**	**60.0 (27)**	**76.0 (38)**	**61.8 (100)**
	Mesomorph–endomorph	0.0 (0)	6.4 (3)	4.4 (2)	4.0 (2)	4.3 (7)
	Endomorphic mesomorph	20.0 (4)	4.3 (2)	6.7 (3)	0.0 (0)	5.6 (9)
	Balanced mesomorph	0.0 (0)	2.1 (1)	0.0 (0)	0.0 (0)	0.6 (1)
	Ectomorphic mesomorph	0.0 (0)	2.1 (1)	0.0 (0)	0.0 (0)	0.6 (1)
	Mesomorph–ectomorph	10.0 (2)	2.1 (1)	4.4 (2)	0.0 (0)	3.1 (5)
	Mesomorphic ectomorph	0.0 (0)	2.1 (1)	0.0 (0)	0.0 (0)	0.6 (1)
	Blanced ectomorph	5.0 (1)	2.1 (1)	0.0 (0)	0.0 (0)	1.2 (2)
	Endomorphic ectomorph	5.0 (1)	6.4 (3)	8.9 (4)	6.0 (3)	6.8 (11)
	Endomorph–ectomorph	0.0 (0)	6.4 (3)	2.2 (1)	0.0 (0)	2.5 (4)
	Ectomorphic endomorph	0.0 (0)	6.4 (3)	4.4 (2)	6.0 (3)	4.9 (8)
	Central	5.0 (1)	4.3 (2)	6.7 (3)	6.0 (3)	5.6 (9)

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Table 3. *Continued*

Somatotype	A + B	C_a	C_b	D + E	Total
Level 3 (9th–12th grade)					
Balanced endomorph	5.9 (1)	5.3 (3)	5 .3 (5)	1.0 (1)	3.7 (10)
Mesomorphic endomorph	**47.1 (8)**	**68.4 (39)**	**74.7 (71)**	**78.4 (80)**	**73.1 (198)**
Mesomorph-endomorph	5.9 (1)	7.0 (4)	2.1 (2)	4.9 (5)	4.4 (12)
Endomorphic mesomorph	11.8 (2)	1.8 (1)	6.3 (6)	2.0 (2)	4.1 (11)
Balanced mesomorph	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
Ectomorphic mesomorph	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
Mesomorph–ectomorph	5.9 (1)	0.0 (0)	0.0 (0)	0.0 (0)	0.4 (1)
Mesomorphic ectomorph	0.0 (0)	0.0 (0)	1.1 (1)	0.0 (0)	0.4 (1)
Blanced ectomorph	0.0 (0)	0.0 (0)	0.0 (0)	1.0 (1)	0.4 (1)
Endomorphic ectomorph	5.9 (1)	3.5 (2)	3.2 (3)	2.0 (2)	3.0 (8)
Endomorph-–ectomorph	0.0 (0)	5.3 (3)	0.0 (0)	0.0 (0)	1.1 (3)
Ectomorphic endomorph	17.6 (3)	8.8 (5)	7.4 (7)	9.8 (10)	9.2 (25)
Central	0.0 (0)	0.0 (0)	0.0 (0)	1.0 (1)	0.4 (1)

See footnote to Table 2 for definitions of SES categories.
High prevalence by group is shown in bold.

registered significant differences in BMI, BF% and endomorphy by SES. When SES decreased, these variables increased. In Level 2, only EC differed, and the tendency for this to increase as SES decreased was maintained. School Level 3 presented differences in BMI, endomorphy and mesomorphy, which tended to increase as SES decreased. In addition, the ectomorph component ($p < 0.05$) decreased as SES decreased. Comparing somatotype as a whole highlighted the fact that all three school levels exhibited extremes in SES: A + B was different from D + E, and C_a was different from D + E.

Table 6 shows the association between high adiposity, as measured by the variables 'high BF%' and 'high endomorph', and SES. Both variables were significantly associated with SES, but low SES increased the risk of high adiposity compared with very high and high SES (high BF%: OR = 2.25; 95% CI 1.40, 3.61; high EC: OR = 2.19; 95% CI 1.37, 3.47). In addition, high adiposity was strongly associated with the female sex for both variables (high BF%: OR = 3.39; 95% CI 2.60, 4.41; high EC: OR = 2.31; 95% CI 1.80, 2.98), and the assessment of school levels revealed that only a high BF% was associated with the second school level.

Figure 1 is a somatochart representing the somatotype of the male sample by SES and school level. This illustrates the distribution between the mesomorph and EC, except for Level 1 when SES was very high, which was more closely associated with mesomorphy. However, a somatochart representing the somatotype of the female sample by SES and school level (Fig. 2) shows that when SES decreases, the groups shift towards endomorphy.

Discussion

This study's assessment of the somatotype of Chilean schoolchildren by sex and school level revealed differences between the sexes, with males presenting a significantly higher

Table 4. Body composition and somatotypes of children ($n = 1168$) by sex and socioeconomic status, 2011–2012, Valparaíso, Chile

		A + B(a)			C_a(b)			C_b(c)			D + E(d)				SDM					
		n	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*p*-value*	a–b	a–c	a–d	b–c	b–d	c–d
Total	BMI	99	$20.22^{c,d}$	3.55	272	20.98^{c}	3.61	409	21.82	3.89	388	21.82	4.57	<0.001						
	BF%	99	26.65	6.99	272	26.96	7.73	409	27.03	8.59	388	27.63	9.65	0.627						
	Endo	99	$4.86^{c,d}$	2.10	272	5.17^{d}	2.25	409	5.64	2.36	388	5.84	2.55	<0.001						
	Meso	99	4.41	1.09	272	4.39^{c}	1.39	409	4.67	1.29	388	4.63	1.38	0.022	0.68	1.89	**2.32**	1.33	1.72	0.49
	Ecto	99	2.11	1.33	272	2.07^{d}	1.37	409	1.80	1.37	388	1.75	1.34	0.004						
Males	BMI	38	20.81	3.99	127	21.29	3.76	216	21.81^{d}	4.11	191	20.71	4.10	0.045						
	BF%	38	22.79	6.75	127	22.99	7.50	216	22.27	7.85	191	21.54	8.53	0.427						
	Endo	38	5.00	2.51	127	5.00	2.66	216	5.28	2.55	191	5.00	2.7	0.642						
	Meso	38	4.75	1.10	127	4.78	1.5	216	4.93	1.28	191	4.78	1.31	0.604	0.24	1.12	0.52	1.02	0.38	0.64
	Ecto	38	2.27	1.40	127	2.17	1.52	216	1.94	1.48	191	2.03	1.37	0.387						
Females	BMI	61	$19.86^{c,d}$	3.23	145	20.70^{d}	3.45	193	21.84	3.65	197	22.90	4.75	<0.001						
	BF%	61	$29.04^{c,d}$	6.02	145	$30.43^{c,d}$	6.10	193	32.37	5.80	197	33.54	6.48	<0.001						
	Endo	61	$4.77^{c,d}$	1.81	145	$5.38^{c,d}$	1.79	193	6.05^{d}	2.06	197	6.65	2.10	<0.001						
	Meso	61	4.20	1.04	145	4.04^{d}	1.19	193	4.38	1.24	197	4.49	1.42	0.012	1.42	**2.90**	**4.24**	1.78	**3.07**	1.34
	Ecto	61	2.02^{d}	1.29	145	1.99^{d}	1.23	193	1.64	1.23	197	1.49	1.26	<0.001						

See footnote to Table 2 for definitions of SES categories.
SDM, somatotype dispersion mean (comparisons in two dimensions of somatotype); significant differences between groups in bold ($p < 0.05$).
BF%, body fat percentage (Ellis equation for Hispanic children). Endo, endomorph component. Meso, mesomorph component. Ecto, ectomorph component.
**p*-values from one-way ANOVA with Bonferroni post hoc test.

Table 5. Body composition and somatotypes of children (n = 1168) by sex, school level and socioeconomic status, Valparaíso, Chile, 2011–2012

			A + B[a]			Ca[b]			C[b]			D + E[d]				SDM					
			n	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*p*-value*	a−b	a−c	a−d	b−c	b−d	c−d
Males																					
Level 1	BMI		10	17.84	2.15	43	20.54[d]	3.76	54	20.12	3.38	68	18.61	3.01	0.004						
	BF%		10	22.69	6.71	43	27.34[d]	7.21	54	26.85	6.70	68	23.41	7.93	0.012						
	Endo		10	3.92	2.19	43	5.93[d]	2.82	54	5.47	2.80	68	4.34	2.46	0.006						
	Meso		10	4.94	1.03	43	5.33	1.20	54	5.29	1.36	68	4.80	1.28	0.087	**5.16**	**4.32**	1.57	0.91	**3.60**	**2.77**
	Ecto		10	2.23	1.15	43	1.26[d]	1.14	54	1.29	1.28	68	1.75	1.05	0.009						
Level 2	BMI		18	21.06	2.99	32	20.47	4.05	86	21.08	3.96	89	21.40	4.09	0.726						
	BF%		18	23.02	7.60	32	21.44	7.59	86	20.63	8.30	89	20.80	8.93	0.721						
	Endo		18	5.76	2.33	32	4.90	2.87	86	5.33	2.65	89	5.68	2.80	0.499						
	Meso		18	4.93	0.92	32	4.59	1.36	86	4.74	1.16	89	4.83	1.34	0.744	**2.31**	1.09	0.19	1.22	**2.16**	0.94
	Ecto		18	2.05	1.32	32	2.52	1.60	86	2.25	1.56	89	2.06	1.51	0.496						
Level 3	BMI		10	23.32	5.19	52	22.41	3.34	76	23.82	3.97	34	23.07	4.22	0.265						
	BF%		10	22.50	5.76	52	20.33	6.04	76	20.86	6.62	34	19.72	8.16	0.670						
	Endo		10	4.73	2.90	52	4.12	2.10	76	5.08	2.23	34	4.52	2.52	0.139						
	Meso		10	4.24	1.37	52	4.45	1.70	76	4.90	1.32	34	4.61	1.34	0.260	1.48	2.35	1.16	**2.86**	1.86	1.77
	Ecto		10	2.70	1.76	52	2.71	1.41	76	2.06	1.38	34	2.49	1.47	0.064						
Females																					
Level 1	BMI		24	17.97[d]	2.42	41	18.71	2.84	53	19.73	2.99	45	20.35	3.96	0.012						
	BF%		24	25.68[d]	5.60	41	27.02	5.66	53	29.02	5.63	45	29.72	6.20	0.018						
	Endo		24	4.15[c,d]	1.63	41	4.83[d]	1.97	53	5.65	2.27	45	6.26	2.11	<0.001						
	Meso		24	4.64	1.04	41	4.61	1.08	53	4.82	0.95	45	4.69	1.36	0.816	1.59	**3.68**	**4.83**	**2.16**	**3.24**	1.35
	Ecto		24	1.88	1.32	41	1.71	1.17	53	1.28	0.95	45	1.35	1.14	0.071						
Level 2	BMI		20	20.17	3.21	47	20.23	3.58	45	20.91	3.16	50	22.00	3.85	0.061						
	BF%		20	29.36	5.70	47	29.26	6.32	45	30.72	5.53	50	32.29	6.44	0.076						
	Endo		20	5.19	2.23	47	5.30[d]	1.85	45	5.67	2.14	50	6.58	1.90	0.007						
	Meso		20	4.16	0.93	47	3.90	1.20	45	4.18	1.26	50	4.28	1.22	0.456	0.79	1.04	**3.21**	1.14	**3.21**	**2.19**
	Ecto		20	2.17	1.33	47	2.33	1.30	45	2.09	1.41	50	1.75	1.44	0.223						

Table 5. *Continued*

		A + B[a]			Ca[b]			C[b]			D + E[d]				SDM					
		n	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*p*-value*	a−b	a−c	a−d	b−c	b−d	c−d
Level 3	BMI	17	22.18	2.69	57	22.53[d]	2.83	95	23.46	3.46	102	24.47	4.90	0.010						
	BF%	17	33.41	3.90	57	33.86	4.29	95	35.02	4.71	102	35.84	5.66	0.055						
	Endo	17	5.18[d]	1.26	57	5.85[d]	1.48	95	6.45	1.83	102	6.86	2.18	<0.001						
	Meso	17	3.61	0.92	57	3.75[d]	1.13	95	4.22	1.31	102	4.50	1.55	0.003	1.41	**2.90**	**4.04**	1.61	**2.78**	1.16
	Ecto	17	2.03	1.26	57	1.91	1.17	95	1.64	1.21	102	1.42	1.20	0.050						

See footnote to Table 2 for definitions of SES categories.
SDM, somatotype dispersion mean (comparisons in two dimensions of somatotype); significant differences between groups in bold ($p < 0.05$).
Level 1, 1st–4th grade. Level 2, 5th–8th grade. Level 3, 9th–12th grade. BF%, body fat percentage (Ellis equation for Hispanic children). Endo, endomorph component. Meso, mesomorph component. Ecto, ectomorph component.
**p*-values from one-way ANOVA with Bonferroni post hoc test.
High prevalence by group is shown in bold.

Table 6. Associations between high percentage body fat and high endomorph component and socioeconomic status in schoolchildren ($n = 1168$) after controlling for sex, school level and height, Valparaíso, Chile, 2011–2012

	High BF%[a]		High endomorph[b]	
	OR	95 %CI	OR	95 %CI
Sex (female)	3.39**	2.60–4.41	2.31**	1.80–2.98
SES[c]				
D + E (low)	2.25**	1.40–3.61	2.19**	1.37–3.47
C_b (medium)	1.88*	1.18–3.01	1.94*	1.22–3.08
C_a (medium–high)	0.67	0.41–1.09	0.77	0.48–1.26
School level				
Level 2 (5^{th}–8th grade)	0.50*	0.33–0.78	0.92	0.60–1.39
Level 3 (9^{th}–12th grade)	0.56	0.31–1.00	0.68	0.39–1.21
Height	21.42**	4.84–94.59	4.44*	1.06–18.45
Likelihood ratio (χ^2)	126.50		60.79	
Hosmer–Lemeshow	$p = 0.347$		$p = 0.331$	
Correctly classified (%)	63.44		60.62	

[a]Defined as BF% ≥25 in boys and ≥30 in girls.
[b]Defined as ≥5.5 in the endomorph component of somatotype.
[c]Definition according to the ESOMAR survey.
*$p < 0.05$; **$p < 0.001$.

mesomorph component at each school level, as previously reported in the literature (Lizana *et al.*, 2012, 2015; Martínez *et al.*, 2012). In contrast, females were more endomorphic than males, a difference that was most significant in the third (later) school level, and which has also been reported previously (Lizana *et al.*, 2012, 2015). Another study of adolescents (15–18 years of age) conducted in Valparaíso between 2009 and 2010 reported that the somatotype of adolescent females was mainly endomorphic (i.e. mesomorph–endomorph in profile) and differed from that of males; although the mesomorph component was significantly higher in males than in females, the endomorph–mesomorph biotype was dominant (Lizana *et al.*, 2015). This is in contrast to the mesomorph–endomorph profile that was identified as dominant in this study.

In females, this study found an increase in the endomorphic character of schoolchildren as SES decreased. This phenomenon is important because a strong relationship between EC and adiposity has been reported (Slaughter *et al.*, 1988); this was reported in the current study as a correlation between increased BF% and low SES. Values of EC greater than 5.5, which correspond to high relative adiposity, in lower SES females are concerning and were maintained across all school levels.

The possible association of socioeconomic status with adiposity is a subject of concern worldwide (Moreno *et al.*, 2005; Wronka, 2014; Zsakai & Bobzar, 2014). However, few national investigations have used somatotype to evaluate adiposity among children and adolescents. One possible explanation for the association between higher adiposity and low SES is that a low SES family exhibits riskier behaviour, which influences child obesity by affecting physical activity and food intake (Villagran Pérez *et al.*, 2013). Another possible explanation is that Chile is a country in a post-transitional

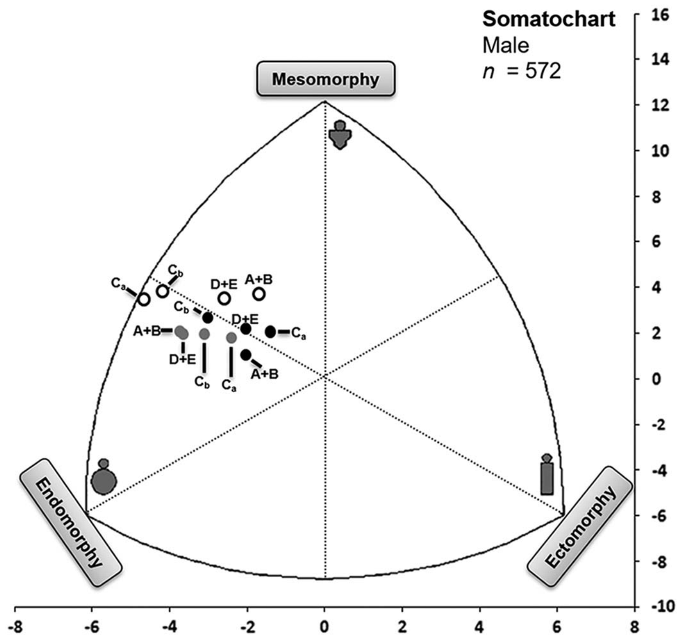

Fig. 1. Somatochart representing the mean somatotypes of the male children sampled from 2011 to 2012 in the region of Valparaíso, Chile, by socioeconomic status (A + B, very high and high; C_a, medium–high; C_b, medium; D + E, medium–low and low) and distributed by school level (white circles = Level 1, 1st–4th grade; grey circles = Level 2, 5th–8th grade; black circles = Level 3, 9th–12th grade).

nutritional stage, with the adoption of a Western lifestyle linked to changes in nutrition and physical activity, including a strong preference for foods with a high caloric content, high in saturated fats and sugar and a decreased intake of vegetables and fruits, accompanied by a reduction in physical activity (Albala *et al.*, 2001, 2002). More than 90% of the Chilean population over 15 years of age are sedentary (JUNAEB, 2014). Moreover, in Chile fruit and vegetables are available at affordable prices in most regions of the country. However, barriers remain for households of low SES, whose members have a fruit and vegetable intake of only approximately half the OMS recommendation (Olivares & Bustos, 2006). The consumption of processed foods with a high energy density is apparently replacing that of fruit and vegetables, possibly because of advertising, availability and low prices across the entire country (Olivares *et al.*, 2007). Food intake preferences are highly related to family context during infancy, when most eating habits are established (Domínguez-Vásquez *et al.*, 2008). Additionally, higher SES groups are more preoccupied with physical appearance than poor groups, particularly females (Liberona *et al.*, 2011). This information matches the results obtained in this investigation when comparing somatotype with SES disintegrated by sex because there was a moderate relative adiposity in women of higher SES in Levels 1 and 2. In school Level 3, adiposity was moderate in individuals of higher SES and increased to high adiposity in the other levels.

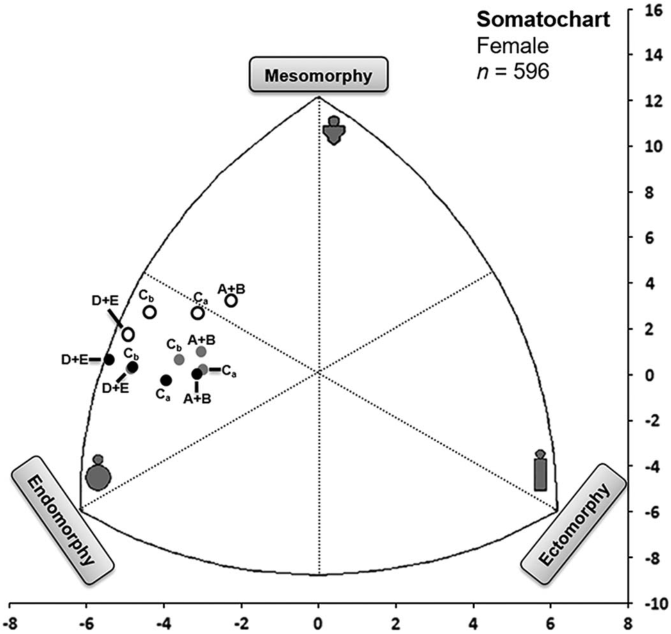

Fig. 2. Somatochart representing the mean somatotypes of the female children samples from 2011 to 2012 in the region of Valparaíso, Chile, according to socioeconomic status (A + B, very high and high; C_a, medium–high; C_b, medium; D + E, medium–low and low) and distributed by school level (white circles = Level 1, 1st–4th grade; grey circles = Level 2, 5th–8th grade; black circles = Level 3, 9th–12th grade).

One limitation of this study is that the participants were sampled from one region of Chile and might therefore not represent other localities. Nonetheless, the region of Valparaíso is the third most populated area of the country (Instituto Nacional de Estadística, 2010), and the sample only represented schoolchildren. An additional limitation was the use of BF% and EC but not the body fat distribution and free fat mass in children. However, a higher BF%, by itself, is known to be associated with obesity co-morbidities (Williams *et al*., 1992). Another limitation was the stratification of the sample by school levels and not by age. Nevertheless, the stratification performed in this study is of greater use for public policy interventions, which are not made by age but by school levels. Moreover, a third study limitation was its cross-sectional design, which prevented drawing conclusions regarding the temporality of the relationships.

The results obtained in this investigation indicate that low SES female children and adolescents should be the focus of Chilean public and school health efforts to increase weekly time devoted to physical activity, promote healthy eating and implement an active curriculum. In addition, future interventions should consider SES inequalities in obesity to achieve better outcomes for this variable (Beauchamp *et al*., 2014). The study provides evidence that significant differences in the endomorph component of somatotype are related to SES school level; furthermore, the female sample showed greater differences in SES-associated adiposity.

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