Letter to the Editor

Obesity, Body Fat Distribution, and Physical Activity in School-age Children: an Urban and Rural Comparison in Valparaíso, Chile*

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This study analyze the relation between body composition, physical activity (PA), and sex in Chilean children from rural and urban public educational institutions. The prevalence of obesity (according to BMI) was 30.88% in urban children and 28.93% in rural children. Central obesity presented mainly in the rural girls. Approximately 90% of the participants reported <7 h of PA/week, regardless of residential area. In addition, central fat was strongly associated with rural residence; the children reported lower PA levels, and they presented a higher prevalence of central fat. The results reflect the need to implement programs to improve PA conditions in the child urban-rural population.

The nutritional status of schoolchildren varies significantly according to geographical area. Current international studies represent an important body of work on the differences between the nutritional status of individuals in rural areas and that of individuals in urban areas.

With regard to South America, data show that greater urbanization is associated with the degree of overweight and obesity in children. In Chile, high BMI levels were reported in both urban and rural children; over 20% of urban and rural children presented with obesity in the first year of school in 2013[1].

In terms of physical activity (PA), there are important discrepancies in the literature about rural and urban contexts[2-4]. In this respect, a Chilean report showed that 90% of primary school students (eighth grade) had inappropriate physical conditions[5]. These urban/rural discrepancies and deficient PA in Chilean schoolchildren demonstrate the need for further investigation to generate efficient interventions in rural and urban contexts, in accordance with well-supported risk factors. Therefore, the aim of the current study was to analyze whether body composition, PA, and sex of children in the region of Valparaíso, Chile vary, according to urban and rural areas.

A transversal descriptive, comparative study was conducted. The target population comprised all rural and urban students aged 8 to 13 years in public educational establishments (receiving a 100% subsidy from the government) in the region of Valparaíso. Data were collected between March 2013 and December 2014. To obtain the sample, rural and urban educational institutions in the provinces of Quillota (32°52'00"S 71°14'00"O) and Valparaíso (33°02'00"S 71°33'00"O), located in the region of Valparaíso, were selected. The rural school population comprised students from three towns in the province of Quillota (Hijuelas, La Calera, and Quillota). The urban population was selected from three towns in the province of Valparaíso (Concón, Viña del Mar, and Valparaíso). Rural and urban schools were defined according to the data provided by the Ministerial Secretariat of Education of Chile. The final student sample comprised randomly selected volunteers from the second and eighth grades of seven urban institutions and seven rural institutions, producing a sample of 363 students (urban 204; rural 159).

The evaluations were conducted at the educational establishments in the morning. The students' weight and height were measured while they wore minimal clothing and no coats or shoes. The anthropometric appraisal comprised the following four variables: 1) height, 2) body mass, 3) triceps skinfold (TS), and 4) subscapular skinfold

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(SS). The evaluations were measured on the right side.

Body mass index (BMI, kg/m^2) was determined and classified according to the 2007 WHO standards (*Z*-score) as follows: low weight, ≤-1 standard deviation (SD); normal, -0.9 to 0.9 SD; overweight, 1.0 to 1.9 SD; and obese, ≥2.0 SD. The percentage body fat (%BF) was calculated using the formulas derived from the Ellis equations for Hispanic children. Adiposity was categorized with differentiation by sex. Obesity was classified according to %BF, with ≥25% BF in boys and ≥30% in girls defined as obesity. The distribution of BF (central or peripheral) was evaluated using the subscapular-tricipital index (S/TI), which was calculated as the ratio between SS and TS, with scores >1 representing a high risk of central obesity.

PA was evaluated using a survey[6]. The survey was validated for the Chilean population through a comparative study using measurement monitors with accelerometers. The validation study found significant associations between the questionnaire and the objective measures and a test/re-test reliability of 0.69 to 0.93 according to Lin's coefficient. The regular PA of the sample was based on responses regarding weekly hours of exercise or scheduled games; further, their PA was categorized as at least 2 h or 2-4 h, which could be attained through participation in physical education classes at school, and over 4 h from participation in extracurricular activities (sports that are practiced outside of regular school hours, such as physical education, aerobic gymnastics, soccer, basketball, tennis, and/or other reported activities) either at the school site or elsewhere. In relation to the minimal PA standards established by the WHO for 5- to 17-year-olds, PA was also categorized as <7 weekly hours of activity (not recommended for good health) or ≥7 weekly hours (recommended for good health) to establish the proportion of the child population that met the criteria for good health. Both categories, PA standards established by the WHO, and regular school PA were based on the same PA survey.

Continuous descriptive statistics were presented as the means and SD and percentages, whereas categorical variables were presented as the number of cases and percentages. The normality of the data distribution was evaluated for each appraisal using the Shapiro-Wilk test. Because not all variables were normally distributed, the Mann-Whitney test was used to detect significant differences between sex and geographical area. The Chi-square (χ^2) and Fisher's Exact Test were used to analyze the associations among categorical variables. Logistic regression analyses were performed to assess the relation between central obesity (exposure) and rural area (outcome) using three models. The first model comprised rural area, obesity by %BF, obesity by BMI, and PA. The second and third models of sex and age, respectively, were included. All statistical analyses were performed using the SPSS software version 15 (SPSS Inc., Chicago, IL, USA).

Participation in the research project was voluntary. Informed consent was signed by the children's parents/legal guardians, school education director, and the students themselves. This assent (which corresponded to a simplified and comprehensible text for children aged 6 to 13 years) was approved by the Ethics Committee of Pontificia Universidad Católica de Valparaíso, Chile, in accordance with the policies of the Declaration of Helsinki.

For age, weight, height, BMI, and TS, no significant differences were found. There were differences in %BF (P<0.001) between the urban boys and girls (22.10±7.89; 30.10±6.92, respectively), as well as between the rural boys and girls (22.22±8.75; 29.96±6.23, respectively). There were also differences in SS (P=0.015), skinfold summation (P=0.043), and S/TI (P=0.005) between the rural boys and girls. Between the urban and rural boys, significant differences were detected in S/TI (P=0.005). The urban and rural girls also differed significantly in terms of these variables (S/TI P<0.001).

Sex-related associations with the body composition variables were observed (Table 1). A significant association between the urban area and BMI was obtained (P=0.012), with an obesity prevalence of 35.94% in boys and 22.37% in girls (P=0.012). There was also a significant association between %BF and urban area (P=0.033), with a higher percentage of obesity in girls (55.26%). In the rural area, a higher percentage of central BF distribution (S/TI P=0.007) was found in girls (36.11%) than in boys (17.24%). There were sex associations in the WHO criteria of PA (P=0.010) and the school-based category of physical education (P=0.001). A high percentage of the total sample did not meet the 7 weekly hours of PA (90.23% of the male and 97.30% of the female participants), indicating that boys perform more PA than girls, regardless of residential area.

The prevalence of obesity in the study was

30.88% and 28.93% in urban and rural children respectively. No significant associations between area and BMI or between %BF and PA (WHO criteria) were found (Table 2); however, there were important associations between S/TI (P=0.033) and urban *vs.* rural residence, indicating a higher percentage of central BF distribution in rural individuals (25.79%). S/TI differences were found in female participants according to area (P=0.005); the rural girls had higher values of central BF distribution (36.11%) compared with those of their urban peers (15.79%). The categorization of the curricular and extracurricular PA hours showed an association with area (P<0.001), indicating that a higher percentage of rural children engaged in 2 to 4 weekly hours of PA and of urban children in <2 h of PA.

Table 3 shows the results of the logistic regression analysis between central obesity and residential area, after controlling for obesity, sex, and age. Rural area increased the risk of central adiposity compared with that in urban peers (model 1: OR=1.87, 95% CI=1.06, 3.32; model 2: OR=1.79, 95% CI=1.00-3.19; model 3: OR=1.83, 95% CI=1.02-3.28). In addition, obesity by BMI was associated with central adiposity in all three models. In the full model, a significant relationship between obesity by BMI and female sex was observed (OR=2.20; 95% CI=1.17-4.16).

The prevalence of underweight, according to BMI, reported in the target population did not exceed 3.95%. This finding is concordant with that of the JUNAEB report, which established a 2.10% prevalence of underweight in the region of Valparaíso[1].

There were no significant associations between the geographical areas, which may be related to the 'rbanization' of rural areas along with the rise in technology and improvements in the transportation system[7]. The reported prevalence resembles figures from a JUNAEB report conducted in the same year, which determined an obesity prevalence of 25.1% in urban children and 23.4% in rural children[1]. These results indicate an increase in obesity prevalence among child populations during the last several years. Such increase in child obesity prevalence resembles findings in other Latin-American countries. Studies in Argentina reported similar obesity values based on geographical distribution (urban 9.7%; rural 9.8%)[7].

Table 1. Association of Body Mass Index, Body Fat, Central/Peripheral Fat Distribution and Physical Activity for Urban or Rural Area and Sex, Valparaíso-Chile, 2013-2014

Item	Total Sample			Urban			Rural		
	Male % (*n*)	Female % (*n*)	*P*-value[a]	Male % (*n*)	Female % (*n*)	*P*-value	Male % (*n*)	Female % (*n*)	*P*-value
BMI[b]									
Obesity	36.28 (78)	20.95 (31)	**0.002**	35.94 (46)	22.37 (17)	**0.012**	36.78 (32)	19.44 (14)	**0.018**
Overweight	24.65 (53)	39.86 (59)		25.00 (32)	38.16 (29)		24.14 (21)	41.67 (30)	
Normal	38.14 (82)	37.16 (55)		39.06 (50)	35.53 (27)		36.78 (32)	38.89 (28)	
Underweight	0.93 (2)	2.03 (3)		0 (0)	3.95 (3)		2.30 (2)	0.00 (0)	
%BF[c]									
Obesity	39.53 (85)	54.73 (81)	**0.004**	39.84 (51)	55.26 (42)	**0.033**	39.08 (34)	54.17 (39)	0.057
Normal	60.47 (130)	45.27 (67)		60.16 (77)	44.74 (34)		60.92 (53)	45.83 (33)	
S/TI[d]									
Central	17.21 (37)	25.68 (40)	0.05	17.19 (22)	15.79 (12)	0.796	17.24 (15)	36.11 (26)	**0.007**
Peripheral	82.79 (178)	74.32 (110)		82.81 (106)	84.21 (64)		82.76 (72)	63.89 (46)	
PA[e,1]									
<7 h	90.23 (194)	97.30 (144)	**0.01**	88.28 (113)	97.37 (74)	**0.033**	93.10 (81)	97.22 (70)	**0.294**
≥7 h	9.77 (21)	2.70 (4)		11.72 (15)	2.63 (2)		6.90 (6)	2.78 (2)	
PA[e,2]									
<2 h	33.49 (72)	35.50 (53)	**0.001**	40.63 (52)	42.11 (32)	**0.007**	22.99 (20)	29.17 (21)	**0.153**
2-4 h	37.21 (80)	50.68 (75)		24.22 (31)	40.79 (31)		56.32 (49)	61.11 (44)	
>4 h	39.30 (63)	13.51 (20)		35.16 (45)	17.11 (13)		20.69 (18)	9.72 (7)	

Note. [a]Chi-square test or Fischer Exact Test for comparison of variables; [b]Nutritional Status defined with WHO reference (for age *Z*-score); [c]Body fat percentage was evaluated by Ellis equations for Hispanic Children; [d]Subscapular/tricipital index; [e]Physical activity, sport curricular and extracurricular activities, [1]WHO recommendations and [2]school-based physical education.

The prevalence of overweight (obesity and overweight) found in the current study, which was nearly 55%, reflects one of the highest rates ever registered in South America. The JUNAEB report (2013) showed a prevalence of overweight above 50% (51.8%) in a first-year primary school population in Chile[1]. These results support the existence of an alarming rise in overweight prevalence, which has also increased in recent years in Chilean schoolchildren.

When the variable BMI is associated with sex, a higher prevalence of obesity is found in boys (36.28%) than in girls (20.95%). In turn, obesity prevalence reports based on BMI are lower than those based on %BF (boys: 39.53%; girls: 54.73%). The differences between these results reinforce the idea that BMI underestimates the apparent health problem[8].

Table 2. Association of Body Mass Index, Body Fat, Central/Peripheral Fat Distribution and Physical Activity for Sex from Urban and Rural Area, Valparaíso-Chile, 2013-2014

Item	Total Sample			Male			Female		
	Urban % (*n*)	Rural % (*n*)	*P*-value[a]	Urban % (*n*)	Rural % (*n*)	*P*-value	Urban % (*n*)	Rural % (*n*)	*P*-value
BMI[b]									
Obesity	30.88 (63)	28.93 (46)	0.961	35.94 (46)	36.78 (32)	0.471	22.37 (17)	19.44 (14)	0.464
Overweight	29.90 (61)	32.08 (51)		25.00 (32)	24.14 (21)		38.16 (29)	41.67 (30)	
Normal	37.75 (77)	37.74(60)		39.06 (50)	36.78 (32)		35.53 (27)	38.89 (28)	
Underweight	1.47 (3)	1.26 (2)		0 (0)	2.30 (2)		3.95 (3)	0.00 (0)	
%BF[c]									
Obesity	45.59 (93)	45.91 (73)	0.951	39.84 (51)	39.08 (34)	0.911	55.26 (42)	54.17 (39)	0.893
Normal	54.41 (111)	54.09 (86)		60.16 (77)	60.92 (53)		44.74 (34)	45.83 (33)	
S/TI[d]									
Central	16.67 (34)	25.79 (41)	**0.033**	17.19 (22)	17.24 (15)	0.992	15.79 (12)	36.11 (26)	**0.005**
Peripheral	83.33 (170)	74.21 (118)		82.81 (106)	82.76 (72)		84.21 (64)	63.89 (46)	
PA[e,1]									
<7 h	91.67 (187)	94.97 (151)	0.296	88.28 (113)	93.10 (81)	0.242	97.37 (74)	97.22 (70)	0.956
≥7 h	8.33 (17)	5.03 (8)		11.72 (15)	6.90 (6)		2.63 (2)	2.78 (2)	
PA[e,2]									
<2 h	41.18 (84)	25.79 (41)	**<0.001**	40.63 (52)	22.99 (20)	**<0.001**	42.11 (32)	29.17 (21)	**0.044**
2-4 h	30.39 (62)	58.49 (93)		24.22 (31)	56.32 (49)		40.79 (31)	61.11 (44)	
>4 h	28.43 (58)	15.72 (25)		35.16 (45)	20.69 (18)		17.11 (13)	9.72 (7)	

Note. [a]Chi-square test or Fischer Exact Test for comparison of variables; [b]Nutritional Status defined with WHO reference (for age *Z*-score); [c]Body fat percentage was evaluated by Ellis equations for Hispanic Children; [d]Subscapular/tricipital index; [e]Physical activity, sport curricular and extracurricular activities, [1]WHO recommendations and [2]school-based physical education.

Table 3. Association between Central Obesity and Residence Area in Schoolchildren from Valparaíso, Chile, after Controlling for Sex, Obesity, Physical Activity, and Age (*n*=363), 2013-2014

Item	Central Obesity[a]								
	Model 1			Model 2			Model 3		
	OR	95 % *CI*	*P*	*OR*	95% *CI*	*P*	*OR*	95% *CI*	*P*
Rural area	1.87	1.06-3.32	0.032	1.79	1.00-3.19	0.049	1.83	1.02-3.28	0.041
Obesity (by %BF)[b]	2.97	1.43-6.17	0.004	2.19	1.02-4.71	0.045	2.11	0.97-4.59	0.058
Obesity (by IMC)[c]	3.13	1.59-6.16	0.001	4.7	2.18-10.12	<0.001	4.92	2.27-10.69	<0.001
PA>4 h	0.84	0.46-1.55	0.575	0.78	0.42-1.46	0.444	0.78	0.42-1.46	0.439
Sex (female)	-	-	-	2.24	1.19-4.22	0.012	2.20	1.17-4.16	0.015
Age	-	-	-	-	-	-	1.11	0.91-1.36	0.296
Hosmer-Lemeshow	-	-	0.134			0.245			0.111
Correctly classified (%)	78.51			79.34			78.51		

Note. PA, physical activity. BMI, body mass index. %BF percentage body fat. [a]was evaluated using the subscapular-tricipital index; [b]was defined as ≥25 BF% in boys and ≥30 BF% in girls; [c]was defined as BMI *Z*-score for age and sex ≥2.0 standard deviations.

It was established that the female population had the highest relevant skinfold thickness values because in a previous study, important significant differences between the sexes were also found in the same skinfolds among adolescents[9]. This finding indicates that this increased adiposity in girls develops at early stages and is maintained during adolescence.

The distribution of BF indicated that a high percentage of central fat was associated with rural children. In addition, central fat had a higher prevalence in rural girls (36.11%), which could indicate that this population is likely to experience health issues[10]. Central fat mass accumulation is associated with a higher probability of developing cardiovascular pathologies, unlike appendicular fat distribution[10].

The importance of these results lies in knowing not only the present %BF in an individual but also in the distribution of this adipose tissue within the body, which is more closely related to the risk of developing pathologies associated with central BF distribution[7,10].

These results are related to the PA data, which showed that 90% of the subjects obtained less than the minimum 7 weekly hours of PA. This PA decrease is associated with rapid technological changes and improvements in transportation[9]. The results may be affected by sociocultural or environmental factors that contribute to changes in the child nutritional profile.

Studies suggest that rural populations are typically more active than urban populations, and the current study arrived at the same conclusion[2,4]. Recently, sex-specific differences were reported, with rural girls being more active than urban and suburban girls[3]. However, not all studies agree on such significant differences, which prevents the establishment of a relevant discrepancy between PA and the population's residential areas[2,4]. The current study found that urban boys were more likely than the other subgroups to engage in PA for ≥7 h per week (11.72%); however, the PA levels of the total sample were greatly lower, indicating that most of the subjects did not comply with the level of PA required for health benefits. National studies agree that the number of hours dedicated to physical education does not meet the basic requirements established by the WHO[5]. The levels and distribution of obesity found in this investigation suggest that PA must be used as a tool to manage overweight. Little time is designated for PA outside of educational establishments; therefore, a solution could be aimed at increasing the time and intensity of exercise during academic hours.

Some limitations of this study were that the student volunteers resided only in the region of Valparaíso, Chile. Owing to this factor, the results could not be generalized to all school-aged populations; hence, it would be interesting to conduct similar studies in other places and with other age ranges. Another limitation was that the questionnaires used to report PA did not include the variable of exercise intensity. Similarly, another important issue to consider in subsequent studies is dietary intake. Finally, the present study had a cross-sectional design, which prevents drawing conclusions on the temporality of the associations.

In summary, this study shows that Chilean children present a higher prevalence of obesity in urban areas than in rural areas, and there is an important incidence of central fat, mainly among children in rural areas. In addition, children of both areas do not comply with the minimum recommended 60 min of PA per day. One cause of the observed higher body fat and lower PA level may be that public health policies have not been clear, sustained, or coordinated by the appropriate entities. A multidisciplinary effort by a team of teachers and health experts would strengthen the health protection and promotion measures aimed at a designated population.

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