RESEARCH PAPER

Trends in weight, height, BMI and obesity in schoolchildren from Santa Rosa (Argentina), 1990–2005/07

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Abstract

Aim: To assess secular changes in physical growth and the current prevalence and trend of overweight/obesity in Argentinian schoolchildren.
Subjects and methods: One thousand and forty-nine schoolchildren aged 6 and 12 years attending schools in 1990 were compared with an age-matched sample of 935 boys and girls collected between 2005–2007. Changes in weight, height and BMI by age between the surveys were analysed using one-way analysis of variance. Overweight and obesity were defined according to IOTF criteria and compared by Chi-squared test. Odds ratios (OR) and intervals of confidence (95% CI) were also calculated.
Results: Six and 12 year-old boys and girls were significantly heavier (1.2–3.2 kg) and had higher BMIs (0.7–1.0 kg/m^2) in 2005–2007 than in 1990. Significant differences in height were seen in 6 year old boys (1.5 cm) and 12 year old girls (1.3 cm). Overweight and obesity increased by 4.4% (OR = 1.4, 1.1–1.8) and 5.9% (OR = 4.3, 2.8–6.5), respectively; obesity being higher in younger children.
Conclusion: The disharmonic secular change in weight and height has led to high overweight/obesity. The obesity increase is consistent with global and regional trends, indicating a shift in BMI distribution, especially at the higher centiles.

Introduction

Long- and short-term changes in physical growth have been widely described in developed countries, especially in those with regular growth surveillance systems. The literature has extensively documented positive secular changes in weight and height during the last century, especially after the Second World War (Cole, 2003; Hauspie et al., 1996; Padez, 2007). It has been said that, in the long-term, secular changes are the outcome of a continuous interaction between genetic and environment factors, while short-time changes (one or a few generations) involve variations in the environment in which growth takes place (Zhen-Wang & Cheng-Ye, 2005). In some countries the growth trend in height has slowed down, reaching a plateau during the last 2 or 3 decades (Kobzová et al., 2004; Krawczynski et al., 2003; Kurokawa et al., 2008; Loesch et al., 2000). Given that the secular trend had occurred very fast to be the result of genetic changes, such slowing down may indicate either an achievement of the growth genetic potential or that social conditions have not continued to improve (Padez, 2007). On the other hand, secular changes in developing countries can still be observed because of current changes in living standards (Ong et al., 2006; Simsek et al., 2005).

Rates of secular changes are not constant over time (Cernerud & Lindgren, 1991; Fredriks et al., 2000; Prebeg et al., 1995; Zhen-Wang & Cheng-Ye, 2005) and may differ by age or sex (Cole, 2003; Fredriks et al., 2000; Hauspie & Vercauteren, 2004; Hauspie et al., 1996; Loesch et al., 2000; Moreno et al., 2000; Parrino et al., 2012). Also, physical traits may be modified with dissimilar intensity (Cardoso & Padez, 2008; Cernerud & Lindgren, 1991; Kryst et al., 2012; Lazarus et al., 2000; Ozer, 2007). In this respect, a global trend towards increased body weight in childhood and adolescence is consequently followed by a rise in overweight and obesity (Wang & Lobstein, 2006).

Evidence of secular growth changes in Latin America has been mainly documented in Venezuela (López-Contreras Blanco et al., 1989), México (Malina et al., 2008), Brazil (Castilho & Lahr, 2001; Marmo et al., 2004) and Chile (Kain et al., 2002; Lizana et al., 2011). In Argentina, studies of secular change have focused primarily on adult height and, with the exception of a study in poor urban children (Lomaglio et al., 1997), the country lacks serial data to analyse growth trends in height, weight, BMI or obesity. Also, as Cardoso & Padez (2008) pointed out, analysis of recent variations becomes difficult either because few data are comparable over time or because those data are not always from comparable samples. This research was possible because

Table 1. Evolution of some socioeconomic and demographic indicators in La Pampa from early the 1990s to early-middle 2000s.

Indicator	1990s	2000s	Source[a]
Santa Rosa (inhabitants)	78 022 (1991)	111 700 (2006)	CNPV (1991); EPH (2006)
Population under 15 years-old	31.7 (1991)	26.2 (2004)	CNPV (1991); MS/OPS (2006)
Population over 65 years-old	7.6 (1991)	10.2 (2004)	CNPV (1991); MS/OPS (2006)
Life expectancy at birth (years of age)	71.6 (1991)	74.8 (2001)	CNPV (1991); CNPV (2001)
Population with UBN (%)[b]	13.5 (1991)	10.3 (2001)	CNPV (1991); CNPV (2001)
Crude death rate/1000 people	7.7 (1991)	7.4 (2004)	CNPV (1991); MS/OPS (2006)
Crude birth rate/1000 people	23.7 (1991)	17.4 (2005)	CNPV (1991); MS/OPS (2006)
Child mortality rate/1000 live births	22.2 (1991)	14.6 (2005)	CNPV (1991); MS/OPS (2006)
Neonatal mortality rate/1000 live births	15.7 (1991)	11.4 (2005)	CNPV (1991); MS/OPS (2006)
Post-neonatal mortality rate/1000 live births	6.5 (1991)	3.3 (2005)	CNPV (1991); MS/OPS (2006)

[a]National population and housing censuses (CNPV, 1991, 2001), Permanent household survey (EPH 2006), Ministry of Health/ Pan American Health Organization (*MS/OPS,* 2006).
[b]Unsatisfied basic needs (UBN) are referred to as direct measures of poverty (household conditions, access to sanitary services, education and economic capacity). The concept is commonly used in Latin American countries.

of the availability of anthropometric data of schoolchildren measured during 2000, in the city of Santa Rosa (La Pampa, Argentinian Patagonia). These data provided by the School Health Office (Ministry of Culture and Education of La Pampa) were taken as the baseline to compare with new data from a cross-sectional survey carried out between 2005–2007 in the same city. The study aims to contribute to knowledge about secular change in physical growth in urban Argentinian schoolchildren aged 6 and 12 years. The study also examines changes in body mass index (BMI) and rates of overweight and obesity, as determined using International Obesity Task Force references (Cole et al., 2000), from 1990–2005/07.

Socioenvironmental and demographic characteristics

La Pampa is located in an area where production systems are developed in natural environments. In the mid-1990s the province was integrated into the Patagonian region. Patagonia (Southern Argentina) is characterized by a low population density resulting from its relatively late settlement along with the displacement of the indigenous population there. Subsequently, the economic and social development of the region has been greatly influenced by settlement policies, such as the movement of army contingents into the region, the implementation of preferential production programmes and higher per capita public investment for social and economic infrastructure, when compared with other regions within the country (Cao & Vaca, 2006).

In 1991, La Pampa had ~290 000 inhabitants, of whom 74.2% lived in urban centres (CNPV, 1991). By 2005, the population had increased to 321 000 and urbanization reached 80% (Anuario Estadístico de la Provincia de La Pampa, 2006). Santa Rosa is the capital city and the main urban centre. By the early 1980s 95% of the urban population were already concentrated there, accounting for 32% of the province inhabitants. By the time of this study the population was ~111 700 people (EPH, 2006). In contrast to the province – which is economically organized around primary production (variety of crop and forage crops and cattle) – the economy of the capital city is concentrated on the service sector, accounting for 60% of the net regional product. In the last few decades, population growth averaged 24% and city expansion occurred along with a concomitant increase in public services and equipment (drinking water, sewage system, natural-gas supply,

paving and public lighting, solid waste collection), covering a large portion of the population's needs. Data from the first semester of 2006 show that the population with unsatisfied basic needs amounts to some 9.0% (3.0% below the national mean), while the income gap is 20 points below the national mean (EPH, 2006). From a socio-demographic and epidemiological point of view the population is ageing, showing an epidemiological profile defined by a predominance of non-communicable diseases as the major causes of morbidity and mortality (MS/OPS, 2006). Apart from the repeated economic crises in the country, especially during 2001 and 2002, several indicators of welfare have improved during the whole period. Table 1 shows some of these in La Pampa.

Methods

Data collection and analysis

The study compared two surveys conducted in Santa Rosa, in 1990 and 2005–2007. Data from the first survey were collected in 1990 by the staff of the School Health Office, Ministry of Culture and Education of La Pampa. It comprised 1649 schoolchildren of 6 ($n = 458$ boys and 439 girls) and 12 years of age ($n = 353$ boys and 399 girls) from all the primary schools of the city. Given the difficulty of making a simple random sampling, the second survey (between 2005–2007) was carried out on a non-probabilistic sample of schoolchildren. We performed a sampling by areas, a sub-type of cluster sampling. Briefly, the city was divided into neighbourhoods and all the schools were identified and mapped. After that, we randomly selected one school in each of the neighbourhoods. In each school selected, all classes were included and all the children were invited to participate. Those of first and seventh grades were selected to be compared with their 1990 age-peers. Since Santa Rosa has only three private schools, we randomly chose one of them. Eventually, the sample included 935 schoolchildren of 6 ($n = 214$ boys and 198 girls) and 12 years of age ($n = 259$ boys and 264 girls).

Permission from the Ministry of Culture and Education was obtained before the study. Informed consent was requested from the parents or legal guardians, who were previously informed about the objectives and methods of the study. At the schools the participation rate was over 90% and

Table 2. Means, standard deviations (in parentheses) and differences in weight, height and BMI of schoolchildren from Santa Rosa (Argentina) between 1990 and 2005/2007.

				Age 6									Age 12					
Variable	Sex	1990	n	2005/2007	n	Mean dif.[a]	F	p-value	Incr./dec.[b]	1990	n	2005/2007	n	Mean dif.	F	p-value	Incr./dec.
Weight	M	22.2 (3.1)	458	23.9 (5.2)	214	1.7	29.13	0.000	1.1	43.0 (9.0)	353	45.4 (11.0)	259	2.4	8.41	0.004	1.5
	F	21.6 (3.3)	439	22.8 (4.8)	198	1.2	14.75	0.000	0.8	44.3 (9.0)	399	47.4 (10.9)	264	3.2	16.72	0.000	2.0
Height	M	117.2 (5.3)	458	118.7 (5.6)	214	1.5	10.64	0.001	0.9	151.4 (7.9)	353	152.2 (7.8)	259	0.8	1.47	0.225	0.5
	F	116.9 (5.7)	439	117.0 (5.8)	198	0.2	3.25	0.099	0.1	152.1 (7.8)	399	153.4 (7.0)	264	1.3	4.98	0.026	0.8
BMI	M	16.1 (1.7)	458	16.9 (2.5)	214	0.7	20.56	0.000	0.5	22.2 (3.1)	353	23.9 (5.2)	259	0.8	9.15	0.003	0.5
	F	15.8 (1.8)	439	16.6 (2.5)	198	0.8	19.43	0.000	0.5	21.6 (3.3)	399	22.8 (4.8)	264	1.0	15.30	0.000	0.6

[a]Difference (absolute values) between means of each survey.
[b]Increase by decade.

only those who were absent on the day of data collection were excluded. The subjects finally included in the analysis represented 20.6% of these age groups within the overall population.

Anthropometric measurements of each child were taken at the school by a single observer (ABO) following standardized procedures (Cameron, 2004). Weight was measured to the nearest 0.1 kg with a digital scale (Tanita BF-350, Tanita Corp., Tokyo, Japan) and height was measured to the nearest 0.1 cm with a mobile stadiometer (SECA S-213, Seca, Hamburg, Germany). The reliability measurements fell within acceptable values.

Changes in weight, height and BMI between the surveys by age were analysed using one-way analysis of variance (ANOVA). Stunting (low height-for-age) was estimated by z-scores under -2 SD of WHO 2007 medians. Thinness (a measure of low BMI-for-age) was calculated according to Cole et al. (2007) and overweight and obesity were calculated according to the cut-offs of the International Obesity Task Force (Cole et al., 2000). Prevalences of nutritional status indicators between surveys were compared by Chi-square test. We also calculated the odds ratios (OR) and the intervals of confidence (95% CI). Statistical significance was set at $p < 0.05$. Statistical analyses were performed using AnthroPlus 1.0.3, Epi Info (TM) 3.5.1 and SPSS v18. All the research protocols were performed following the recommendations of the ethic committee of the Instituto de Desarrollo e Investigaciones Pediátricas (CIRPI, IDIP-MS/CICPBA) and according to the principles expressed in the Declaration of Helsinki.

Results

Descriptive statistics of weight, height and BMI for boys and girls for both surveys by age-group are given in Table 2. Mean weights, heights and BMIs were higher in 2005/07 than in 1990. Also there was an increased variation of weight and BMI expressed by the standard deviations, compared to the stature variation. At 6 years of age, weight increased significantly among boys and girls (1.7 and 1.2 kg, respectively). Boys were also taller than their age-peers surveyed in 1990 (1.5 cm), but not the girls, who remained almost with the same stature (0.2 cm). BMI also increased among boys and girls, averaging 0.75 kg/m². At 12 years of age, weight was higher than in 1990

Table 3. Changes in prevalences (%) of nutritional status between 1990 and 2005/2007.

	Survey				
Indicator	1990 (n = 1649[a])	2005/2007 (n = 935[b])	Chi-square	p-value	OR (95% CI)
Stunting	2.0	1.6	0.5	0.471	No calculated
Thinness	2.9	3.8	0.8	0.985	No calculated
Overweight	12.6	17.0	9.4	0.002	1.4 (1.1–1.8)
Obesity	1.9	7.8	52.6	0.000	4.3 (2.8–6.5)

[a]$n = 811$ boys and 838 girls.
[b]$n = 473$ boys and 462 girls.

(2.4 kg in boys and 3.2 kg in girls). BMI also increased in both sexes (0.8 and 1.0 kg/m², in boys and girls, respectively). In contrast, height changes differed by sex, with a significant increase in girls (1.3 cm) but not in boys (0.8 cm, $p > 0.05$). On average, the change per decade indicates a sharp increase in weight ($0.8 \sim 2.0$ kg) and BMI ($0.5 \sim 0.6$ kg/m²) in relation to height ($0.1 \sim 0.9$ cm), which showed increases of lesser magnitude and variations by age in each sex.

In both surveys rates of stunting and thinness were below 4.0%, exceeding slightly the expected frequency under 2 SD in the reference population. In the same period overweight increased by 4.4% and obesity 5.9%, reaching prevalences of 17.0 and 7.8%, respectively (Table 3). There were no differences between sexes in overweight and obesity, but excess of weight showed a greater magnitude in younger children compared to older ones (Figure 1).

Figure 2 represents absolute differences (1990–2005/07) between the specific centiles (10, 25, 50, 75, 85 and 95th) for each variable. In weight and BMI, the magnitude of differences grew from the 50th centile onwards, meaning greater increases at the upper centiles compared to lower ones. In contrast, differences between height centiles were smaller and its pattern non-uniform.

Discussion

Most research on growth and nutritional status focuses on children under 5 years of age, whereas older children are often omitted from health and nutrition surveillance (Best et al., 2010; de Onis & Blössner, 2000). However, recent studies based on national data have attempted to look at changes over

Figure 1. Changes in prevalences of over-weight (grey bar) and obesity (black bar) between 1990 and 2005/2007; *$p < 0.05$, **$p < 0.01$.
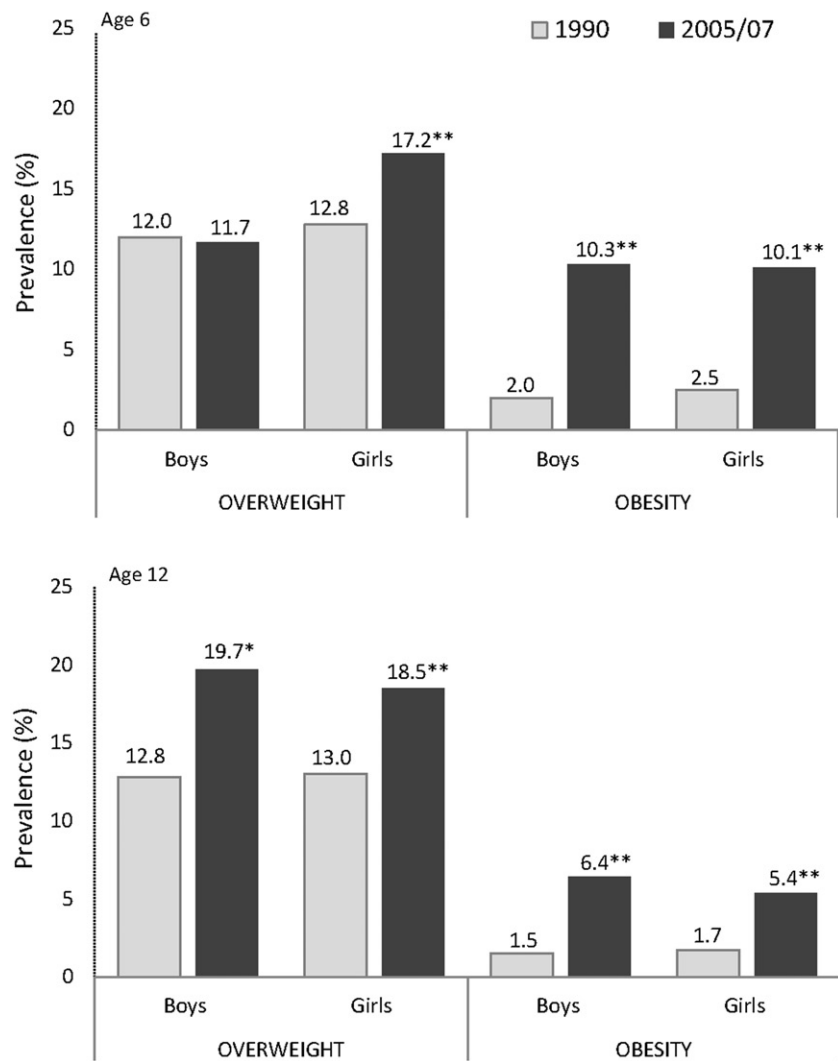
recent decades in older children and adolescents (Fredriks et al., 2000; Haug et al., 2009; Hosseini et al., 2010; Kobzová et al., 2004; Vignerová et al., 2007; among others). Argentina does not have a systematic surveillance of growth and nutritional status in school-aged children, but until the 1990s follow-ups of children who started (6 years old) and ended (12 years old) the primary school were regularly conducted by trained health teams in all the schools in La Pampa. Fortunately, data for 1990 were available to be used in this research as a comparative baseline.

This study evidences positive secular changes in the growth of these Argentinian schoolchildren between 1990 and 2005–2007. This trend, however, was not uniform because of a differential change in weight and height, a variable effect according to age and sex differences in the tempo of growth. In fact, in 2005/2007 boys and girls aged 6 years were, respectively, 1.7 and 1.2 kg heavier than their age-peers in 1990. At 12 years of age such difference attained 2.4 kg and 3.2 kg. Changes in height were restricted to 6 year old boys and 12 year old girls, probably reflecting sexual differences in growth rates, since it is expected these girls, whose age at menarche has been estimated in 12.84 years (Orden et al., 2011), have already reached their height velocity peak. In overall, these changes represent an increase by decade of $0.8 \sim 1.1$ kg and $0.1 \sim 0.9$ cm in pre-adolescents, and

$1.5 \sim 2.0$ kg and $0.5 \sim 0.8$ cm in adolescents. These results suggest a secular pattern defined by low change in stature, while the increase in body weight is still continuing at a high rate (Lizana et al., 2011; Loesch et al., 2000; Kryst et al., 2012; Zellner et al., 2007).

Secular changes occur either by changes in the adult size or changes in the growth rates. There is no available data on adult size for 1990, but recruits born in 1975, aged 18 in 1993, measured 174 cm (PPAN, 1999), almost the same height of those aged-matched boys born in 1991 (Orden, 2011). The studies in this population also found that children and adolescents are taller than their national standards, but retain the same adult size (Orden, 2011; Orden et al., 2009). This evidence suggests a possible secular acceleration of growth or secular trend in tempo of growth, producing a shortening of the whole growth period. This means that children are taller during childhood and adolescence than their counterparts of some decades ago, but this increased growth rate does not affect final size (Cole, 2000; Hauspie & Vercauteren, 2004).

The disharmonic change in weight and linear growth have resulted in an increased BMI among boys and girls of 6 and 12 years of age (0.5 kg/m^2 by decade). Such an increase was not restricted to the mean/median BMI values, but also in the upper centiles. Figure 2 clearly shows that the biggest change
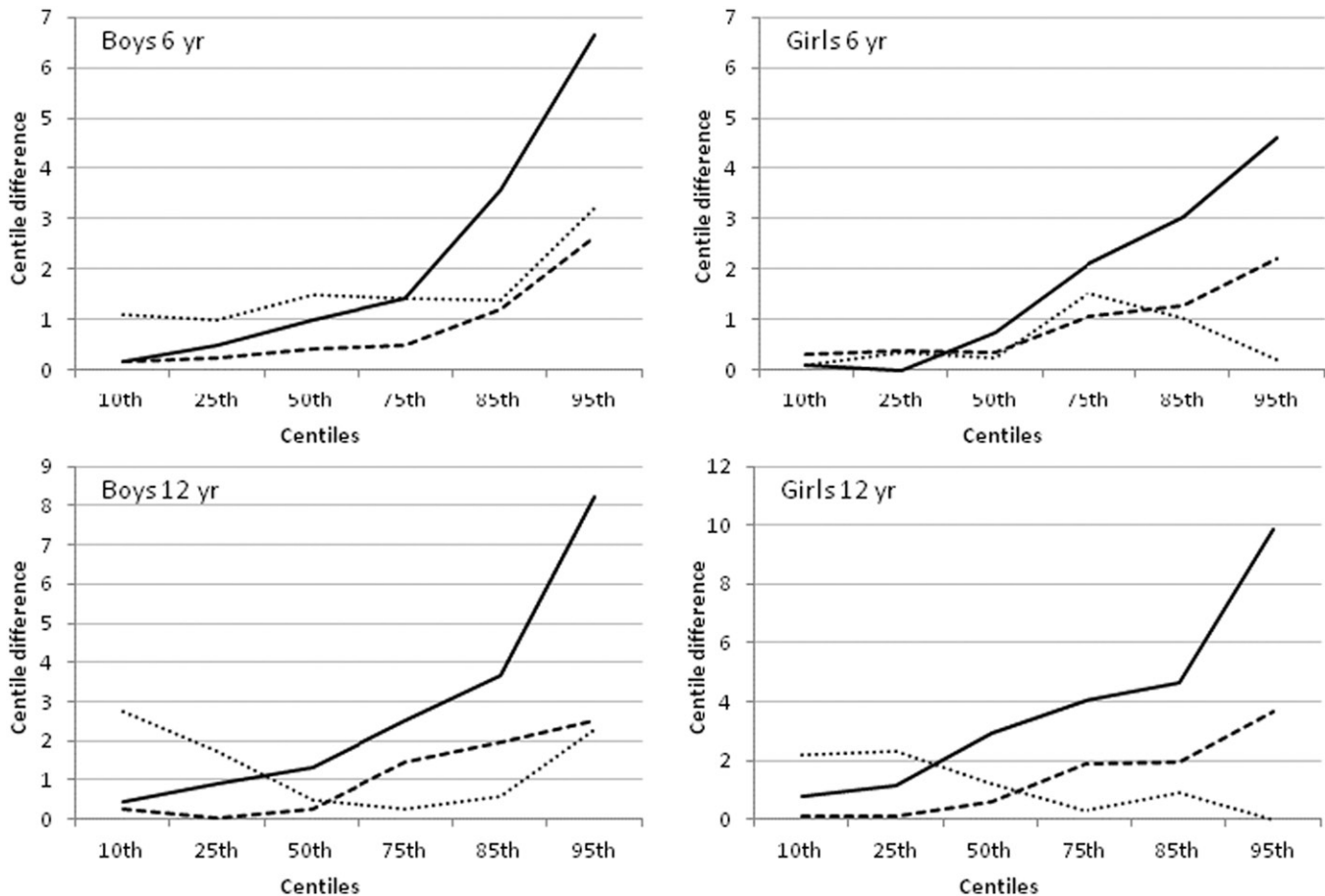
Figure 2. Absolute differences (1990–2005/2007) between selected centiles of weight (solid line), height (dotted line) and BMI (dashed line) in boys and girls aged 6 and 12 years of age.

in BMI occurred at the right tail of the distribution, with relatively little or no change below the 50th centile. This shift of the upper centiles with little or no change in the median has been reported in different populations of children and adolescents (Carrascosa Lezcano et al., 2008; Kautiainen et al., 2002; Lazarus et al., 2000; Moreno et al., 2000; Parrino et al., 2012; Vignerová et al., 2007). It should be noted that many studies have found that obese children increased much more than overweight ones, as a result of the most significant change at the upper centiles, close to the cut-off values that define obesity.

Our results indicate that, between 1990 and 2005/2007, overweight increased by ~40%, while obesity quadrupled, showing similar profiles among boys and girls, but higher prevalences in younger children. With variable figures, this phenomenon has been widely observed in children and adolescents from developed and developing countries, during the last two decades (Wang & Lobstein, 2006). Globally, IASO/IOTF (2012) estimate that up to 200 million school-aged children are either overweight or obese, of those 40–50 million are classified as obese. In 2004, according to IOTF criteria, it was estimated that ~10% of children worldwide aged 5–17 years were overweight and that 2–3% were obese (Lobstein et al., 2004). Prevalence rates vary considerably between different regions and countries, from <5% in Africa and parts of Asia to >20% in Europe and >30% in the Americas and some countries in the Middle East. In Latin America, Mexico and Chile appear to exhibit the

highest rates of overweight, including obesity, ~28%. Our data are close to these reports averaging a global prevalence of 25% (overweight between 14–19% and obesity between 6–10%), above Brazil which figure averages 22%.

Regarding the secular change for each sex, we found sexual dimorphism in changes of height seems to reflect sex differences in maturation. In contrast to other studies that found sexual differences in trend and prevalences of obesity – associated with body image in female adolescents (Chrzanowska et al., 2007; Moreno et al., 2000; Vignerová et al., 2007; among others) – our results were similar among boys and girls. However, we cannot speculate what is the trend at older ages.

To explain these findings means considering environmental causes, in the broadest sense, which have affected the lifestyle, biology and health of the population. At the beginning of the 1990s, Argentina embraced a comprehensive economic reform. In addition to ''dollarization'', it included a massive privatization of public utilities, deep trade and financial expansion and de-regulation of domestic markets (Frenkel, 2002). Despite stop-and-go cycles, the economic course during the 1990s opened to foreign capital influx and new markets for consumer goods and services that became accessible to a large proportion of the population. Thus, living conditions changed as well as lifestyle and consumption patterns. Several wealth indicators improved during the period considered in this study, for example child mortality rates (neonatal and post-neonatal) decreased, along with an

increment in life expectancy at birth. Also mortality and birth rates decreased to that observed in some developed countries. As a result, the size of the population has kept constant, but its structure changed to an ageing profile. Likewise, other health indicators show that cancer and cardiovascular diseases cause 81% of mortality, whereas infections account for less than 10% (MS/OPS, 2006). These figures indicate a change in living conditions, with a kaleidoscopic profile, in which some welfare indicators are close to those of developed countries, while others still define developing countries, for example the population with unsatisfied basic needs.

We think that trends in height and weight resulting from such improvements in health and nutrition have also imposed potential harm to health, given the rising obesity in these schoolchildren. In fact, the food consumption profile showed an increased daily kilocalories intake in terms of carbohydrates and fat, whereas the protein intake was kept rather constant (ENNyS, 2007). Also, a reduction in energy expenditure has resulted from increased use of personal computers and sedentary activities such as watching TV (Barría & Amigo, 2006).

This positive secular change in overweight and obesity in Argentina may be traced to the marked changes in political, economic and social circumstances that took place since the 1990s. The present results only reflect two specific ages in schoolchildren of a particular city, so extrapolation of such results to other ages and geographical settings should be cautious, given the Argentinian diversity in demographic and socioeconomic terms. In contrast, the main strength of our results is that the analysis was done on data that are comparable in terms of population representativeness.

Conclusions

Accelerating rates of overweight and obesity are the result of a relatively greater secular increase in weight compared to that in height. Thus, in a general sense, these schoolchildren are now fatter than their age peers at the beginning of the 1990s. In contrast to the situation found in many transitional countries with double burden of malnutrition, this study shows that stunting and thinness are not relevant. On the contrary, rates of overweight and obesity are alarming, especially in younger children. We cannot establish if these results are temporary associations because of our cross-sectional data, but certainly interventions related to obesity in schoolchildren are needed, perhaps secondary prevention efforts, since obesity in childhood is an important risk factor for adult obesity.

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Declaration of interest

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