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Secular trends in growth among urban Brazilian children of European descent

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Summary. *Primary objective*: The purpose of this paper is to describe and discuss a significant secular trend in stature and weight in an urban Brazilian population.
Methodology: Anthropometric measurements of 7878 children and adolescents from São Paulo, Brazil, obtained in 1997/98 were compared with data from a previous study carried out in 1978. Both samples include children of middle-class urban families of European ancestry.
Main outcomes and results: Comparisons between the two samples reveal strong positive secular trends in both height and weight. Furthermore, the 1997/98 sample shows no growth deficits in relation to the WHO/NCHS international reference.
Conclusions: The positive trend can be explained as the result of economic development and improvement of social indicators, while the absence of growth deficits, contrary to what is reported in other studies carried out in developing countries, follows from the common genetic background of the Brazilian sample surveyed here and the US sample which is the basis of the NCHS/WHO reference.

1. Introduction

The human growth curve is the product of a 5 million year-old history of moulding by natural selection, and represents the 'growth dimension' of human life history (Ulijaszek, Johnston and Preece 1998). But studies of living and past populations, beginning more than two centuries ago, have revealed changes in human growth patterns (Eveleth and Tanner 1990). The short time ranges involved (of the order of a few generations or a single generation) indicate that those 'secular changes' are likely to result not from alterations in the genetic constitution of populations, but in the environment in which growth takes place. The belief that human growth depends on the interaction of genetic and environmental factors, thus being a measure of social welfare, is the keystone of the discipline of anthropometrical history (Fogel 1995).

Secular changes were prominent in the 20th century (especially after World War II) and were expressed as a steady increase in mean height and weight of European and US populations (van Wieringen 1986). Concomitantly, assessments of the age at menarche have revealed progressively earlier ages of puberty onset in adolescents, largely related to improved health, general nutrition and fat content in the diets (Eveleth and Tanner 1990). This context justified the generalization that economic growth implies improvement in living standards, and that urban environments are most favourable to growth (Eveleth 1986). The general conviction that industrializa-

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tion and urbanization have had a positive effect on human growth is the reason why secular changes, 'secular trends', and 'positive trends' are often used as equivalent terms in anthropological studies.

However, positive secular trends are not trivial phenomena. An example that a straightforward association between economic growth and improvement in living standards does not happen necessarily is given by studies based on anthropometrical data from the 18th and 19th centuries, which helped to solve a long-standing debate on the effects of the Industrial Revolution on the social welfare of European and US populations. Careful analyses by Komlos (1993) revealed a decrease in mean height, and thus nutritional status, of British populations in the second half of the 18th century, in spite of rapid economic growth, i.e. a divergence of material and biological trends, contradicting previous analyses by Floud, Gregory and Wachter (1990). In the 1820s, following the end of the Napoleonic wars, a recovery took place, but heights would not reach the values of the 1740s. This was followed by another downturn in the 1840s extending at least to 1870, despite the fact of this being a period characterized by further urbanization and increase in per capita income.

The existence of those cycles in height and nutritional status (Fogel 1995) are certainly not an exclusively British phenomenon. Data from Austria (Komlos 1985) and Sweden (Sandberg and Steckel 1987) show the same downturn in the second half of the 18th century, while the deterioration of living standards during the mid and late 19th century was also present in Montreal, Canada (Ward and Ward 1984) and USA (Komlos 1987). Put together, those studies indicate that there was no direct correlation between industrialization and increase in real wages on the one hand, and better standards of living on the other. As an attempt to explain why this is the case, Komlos (1993) postulates the occurrence of Malthusian crises during episodes of rapid market expansion. Rapid population growth in the cities would lead to a raise in demand for food that could not be covered in the short term. In other words, in spite of the raise in per capita income, demography would lead to a generalized decrease in nutritional status.

It has also been shown that urbanization does not always have positive effects on nutrition and growth. From the 1780s to the first decades of the 19th century, not only were Londoners the shortest British population from which anthropometrical data are available, but a gradient could be observed: the further from London and industrialized midlands and the closer to Scotland and Ireland, the higher the nutritional status and average heights of recruits (Komlos 1993). Those conclusions also hold true for comparisons between urban and rural areas in Central Europe, USA before the Civil War, and even for the less industrialized Japan in the late 19th century, suggesting that the proximity to food sources might have been a critical factor for nutritional status (Komlos 1994). Fogel (1995) argues that rapid urbanization led to an increased exposure to diseases, and thus a deviation of physiological resources away from growth, and that only in the long run was the urban–rural polarity reversed, due to improvements in sanitation and health services in urban areas.

The close association between increases in height, per capita income, food intake and urbanization levels, so characteristic of the 20th century (Bielicki 1986), is thus a recent and perhaps unique phenomenon. First, each episode of social transformation will have its own balance of costs and benefits to growth. Second, the way changes in environment are perceived by human populations depends on social structure. Thus,

in Habsburg, Austria, the upper classes were not affected by the late 18th century crisis, the same holding true for the urban middle class of USA in the 1830–40s. But in France, while military records show a steady increase in height during the 19th century, the Parisian elite became increasingly shorter (Komlos 1994). At the other extreme, countries such as Sweden approached in the 1970s the ideal of a society where social-class gradients in growth do not exist (Lindgren 1976). The dynamic nature of growth response is shown by the fact that differences in height between classes seem to have recently reappeared in Sweden (Lindgren and Cernerud 1992), but not in many other European countries (Cavelaars, Kunst, Geurts *et al.* 2000). Third, genetic differences between populations are supposed to determine not only potential for growth under optimal conditions, but also how individuals respond to changes in social environment (Eveleth 1986), so that African, European and Eastern populations, for example, may differ in their response to the same environmental changes.

For those reasons, Latin American and Asiatic countries represent an interesting opportunity to appraise how human populations respond to waves of social and economic change. Accordingly, after World War II secular changes have been shown to accompany economic development in Japan (Matsumoto 1982), China (Zhang and Huang 1988), Venezuela (Lopez Blanco 1995) and Brazil (Monteiro, Benicio and Gouveia 1994) among others. In the case of Brazil, average economic growth in the 20th century was second only to Japan. The rapid industrialization process initiated in the 1930s was followed by a rise in urbanization (reaching 80% in 1998), and by a sharp increase in income inequality (a gini coefficient of 60.1 in 1995) (World Bank 1999). The ethnic constitution of urban populations is not homogeneous, being represented by European, Middle Eastern, African, Asiatic and Amerindian descendants, the latter more prominent in the north of the country.

In this paper we present new data on growth patterns of a middle-class population of European descent from São Paulo, Brazil, a city of about 10 000 000 inhabitants, most of which descend from European migrants. Its metropolitan area (16 000 000 inhabitants) represents 10% of the country's population. The reason why this study focuses on this particular sample is the existence of a previous anthropometrical survey done in 1978 in the nearby, highly industrialized city of Santo André. This earlier study was based on a large sample of children and adolescents from lower middle-class families of European ancestry. Thus, their socio-economic status is somewhat different from that of the upper middle-class children studied in 1997/98. However, the Santo André child population is described as in good conditions of nutrition and health at the time of the survey (Marques, Marcondes, Berguó *et al.* 1982). The time span of 20 years between the two studies, corresponding to one generation approximately, is appropriate to investigate the pace of secular changes in this population.

2. Materials and methods

A sample of 7878 children and adolescents (3984 boys and 3894 girls) were measured in eight private schools of São Paulo, covering the range from 5 to 18 years of age. In a small number of cases, it was not possible to measure both weight and height of the same individual, and for this reason the total number of weight measurements included in the analyses is 3961 for boys and 3882 for girls, and the total number of height measurements is 3957 for boys and 3872 for girls. Ages of all the individuals were assessed directly from school registers based on birth certificates.

The division in age groups followed the international convention, so that, for example, cohort 5± (represented by '5' in plots) designates children aged 4.5 to 5.49 years. European descendants from middle and upper middle classes predominate at private schools in São Paulo. Children of Asiatic origin, mainly Japanese (about 10%), were excluded from the sample, as well as a few students of African ancestry.

Data collection was performed either by the authors (two schools) or by graduate schoolteachers (five schools) during the end of 1997 and beginning of 1998. The six people responsible for taking the measurements followed a similar procedure, i.e. all anthropometrical measurements took place during classes of physical activities, so that weights and heights were taken with subjects without shoes or heavy clothing. Stature was recorded to the nearest centimetre using standard measuring instruments and, contrary to the suggestion of Cameron (1986), no upward pressure was applied beneath the mastoid process. In five schools, weight was recorded to the nearest 0.1 kg using a conventional scale. In the remaining two schools, a digital scale displaying exact values in intervals of 0.05 kg was used. Differences between values obtained from each scale were not statistically significant (data not shown).

Cross-sectional weight and height curves were created for both sexes. One-sample *t*-tests were utilized to analyse differences between average weights and heights of the 1978 and 1998 samples. Curves and statistical tests were performed using the statistical package SPSS (1998). Comparisons with the National Centre for Health Statistics/World Health Organization (NCHS/WHO) reference curves (NCHS 1978) were performed using the software Epi Info (1995).

3. Results

Mean values and other statistics describing the sample are displayed in tables 1 and 2. *t*-tests indicate that the average weights and heights of boys surveyed in 1998 are significantly above the values of 1978 for all cohorts from 5 to 18 years ($p < 0.001$). In girls, differences between samples reach equivalent levels of significance after 7 years of age. This suggests an upward displacement of growth curves in this interval of 20 years (figures 1–4).

Table 1. Mean weights (in kg), standard deviations (SD) and standard errors of the mean (SE) of boys and girls of European ancestry from São Paulo, Brazil.

	Boys			Girls		
Age	*n*	Mean (SD)	SE	*n*	Mean (SD)	SE
5±	33	20.71 (2.54)	0.44	39	20.21 (3.55)	0.57
6±	58	23.58 (4.29)	0.56	84	22.48 (4.33)	0.47
7±	230	26.9 (4.95)	0.33	216	25.69 (4.28)	0.29
8±	256	29.84 (6.02)	0.38	288	28.9 (5.43)	0.32
9±	259	34.54 (8.6)	0.53	273	31.78 (6.37)	0.39
10±	299	36.55 (7.66)	0.44	273	35.92 (8.29)	0.5
11±	305	42.38 (10)	0.57	315	40.78 (8.55)	0.48
12±	364	46.19 (11.42)	0.6	337	46.37 (11.1)	0.6
13±	394	52.37 (11.29)	0.57	339	49.75 (9.4)	0.51
14±	392	57.1 (12.43)	0.63	396	52.27 (9.37)	0.48
15±	519	63.46 (13.1)	0.57	508	54.37 (8.51)	0.38
16±	453	66.22 (10.1)	0.52	454	55.99 (8.22)	0.39
17±	316	68.75 (10.9)	0.61	316	56.1 (8)	0.45
18±	83	70.82 (9.68)	1.06	44	55.97 (7.86)	1.19

Table 2. Mean heights (in cm), standard deviations (SD) and standard errors of the mean (SE) of boys and girls of European ancestry from São Paulo, Brazil.

	Boys			Girls		
age	*n*	Mean (SD)	SE	*n*	Mean (SD)	SE
5 ±	33	113.27 (4.85)	0.84	39	111.61 (5.24)	0.84
6 ±	58	119.6 (6.55)	0.86	84	117.33 (6.48)	0.71
7 ±	230	125.1 (5.37)	0.35	215	124.17 (5.35)	0.37
8 ±	256	130.68 (5.85)	0.37	290	129.23 (5.78)	0.34
9 ±	259	135.8 (6.69)	0.42	273	134.31 (6.09)	0.37
10 ±	299	139.99 (6.22)	0.36	273	139.49 (6.44)	0.39
11 ±	304	146.31 (8.6)	0.49	313	147.61 (7.54)	0.43
12 ±	363	151.77 (8.36)	0.44	338	154.3 (7.5)	0.41
13 ±	393	159.27 (8.23)	0.41	339	158.54 (6.74)	0.37
14 ±	391	165.51 (8.47)	0.43	386	161.47 (5.76)	0.29
15 ±	519	171.25 (6.91)	0.3	508	162.96 (6)	0.27
16 ±	453	174.59 (7.14)	0.36	455	163.69 (6.39)	0.3
17 ±	316	176.17 (6.74)	0.38	315	164.05 (6.28)	0.35
18 ±	83	176.73 (6.26)	0.69	44	164.9 (5.08)	0.77

In 8-year-old boys, weight increased from 27.1 to 29.9 kg, and height from 128.4 to 130.7 cm, a rate of 1.4 kg and 1.15 cm per decade. In the case of girls, increases from 27 to 28.9 kg and from 127.8 to 129.2 cm correspond to a positive trend of 0.95 kg and 0.7 cm per decade. We compared the Brazilian averages with the NCHS standard, taken by the WHO as the international growth reference of healthy and well-nourished populations (NCHS 1978). It is seen that at the age of 8 years Brazilian boys are 4.6 kg above the NCHS/WHO reference, and are 3.7 cm taller (table 3), while Brazilian girls are 4 kg and 2.8 cm above the reference. The mean values of weight and height for children aged 8 correspond respectively to percentiles 84.08, 75.6 (boys) and 77.49, 68.15 (girls) of the NCHS/WHO reference curves.

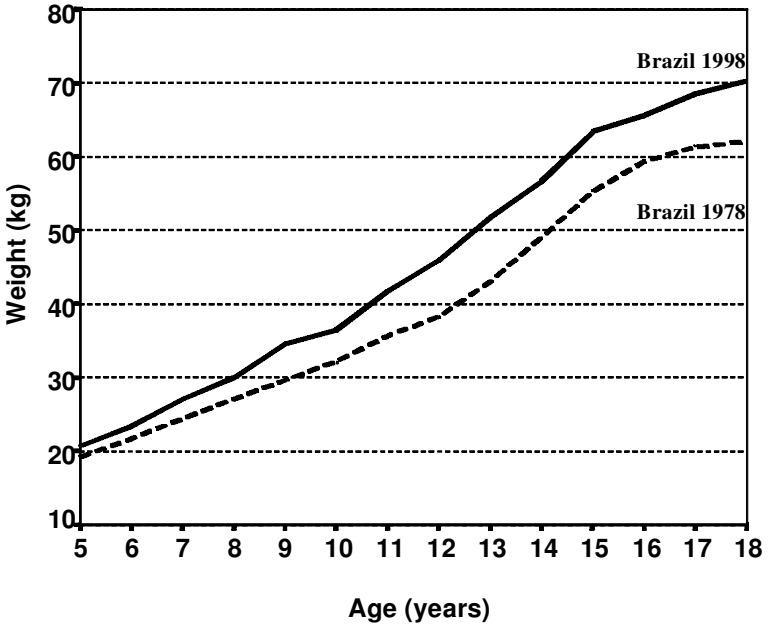

Figure 1. Curve of average weight (kg) for Brazilian boys, 1978–1998.

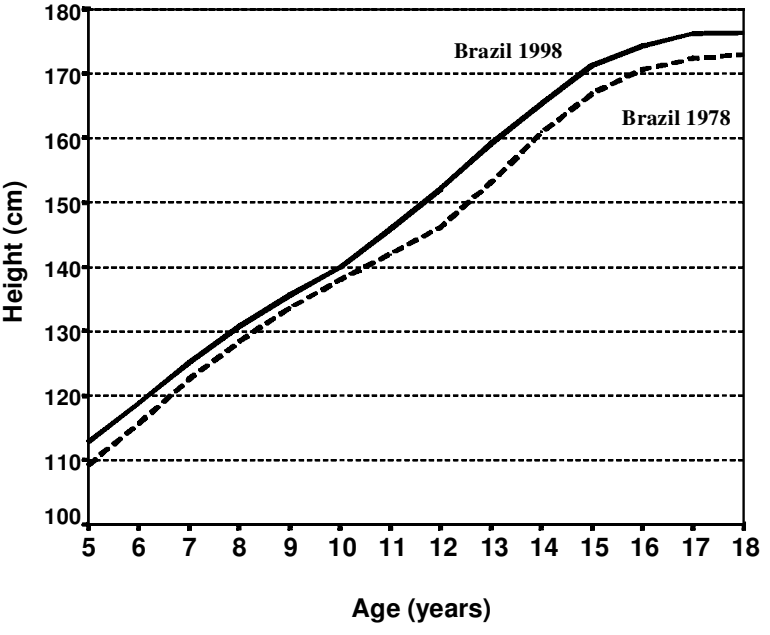

Figure 2. Curve of average height (cm) for Brazilian boys, 1978–1998.

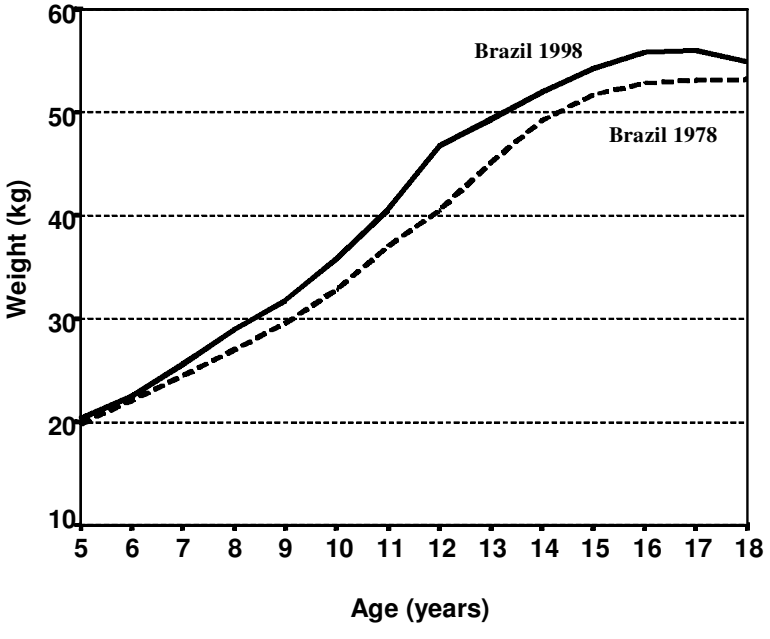

Figure 3. Curve of average weight (kg) for Brazilian girls, 1978–1998.

As regards the 18-year-old population, similarly intense trends are observed. In the period from 1978 to 1998, the increases in average weight and height in males—62 to 70.82 kg, 172.9 to 176.73 cm—and females—53.2 to 55.97 kg, 159.9 to 164.9 cm—represent rates of 4.41 kg and 1.91 cm per decade in males, and 1.39 kg and 2.5 cm in females. But in this case, when comparisons with the NCHS/WHO

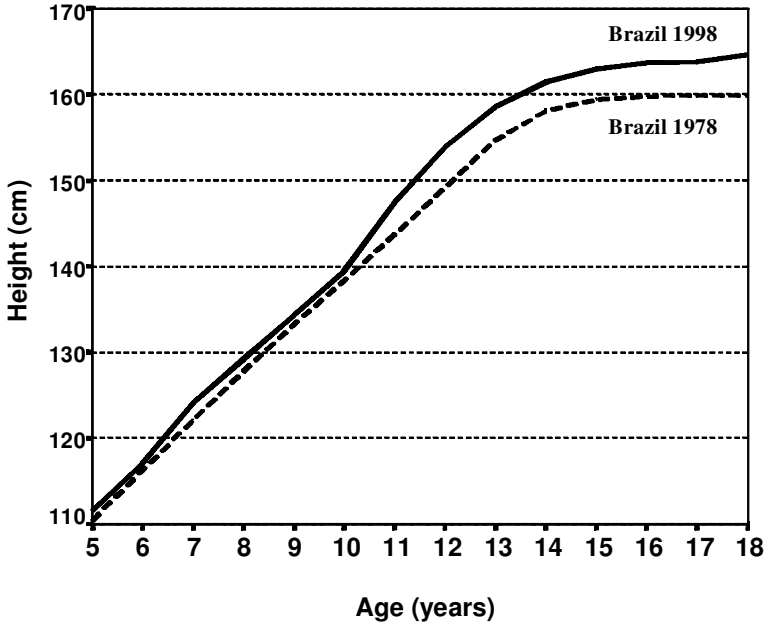

Figure 4. Curve of average height (cm) for Brazilian girls, 1978–1998.

standard are made, interpretations are less straightforward. On the one hand, it is observed that at 18 years both mean weight of Brazilian young men and mean height of Brazilian young women are above the standard (corresponding respectively to percentiles 55.95 and 58.21). On the other hand, height of men and weight of women fall slightly below the reference (percentiles 49.14 and 46.34). It is nonetheless clear that the adult Brazilian sample is much closer to the NCHS/WHO standard than the 8-year cohort.

When average values of the Brazilian sample are converted into percentile values relative to the NCHS/WHO standard and plotted against age group, this decrease can be clearly observed (figure 5). The combination of high weight on the one hand, and height almost equal to the reference value on the other, results in adult Brazilian men being relatively heavy for their height. Adult women exhibit the opposite pattern—height above and weight below the NCHS/WHO reference, leading to a relatively lean female population.

Table 3. Average weight (kg) and height (cm) of Brazilian males and females in selected cohorts, and a comparison with NCHS values.

	Boys			Girls		
	Brazil	NCHS	NCHS percentile of Brazilian mean	Brazil	NCHS	NCHS percentile of Brazilian mean
Weight (kg)						
8	29.94	25.3	84.08	28.9	24.85	77.49
18	70.82	68.73	55.95	55.97	56.64	46.34
Height (cm)						
8	130.68	126.97	75.6	129.23	126.39	68.15
18	176.73	176.83	49.41	164.9	163.66	58.21

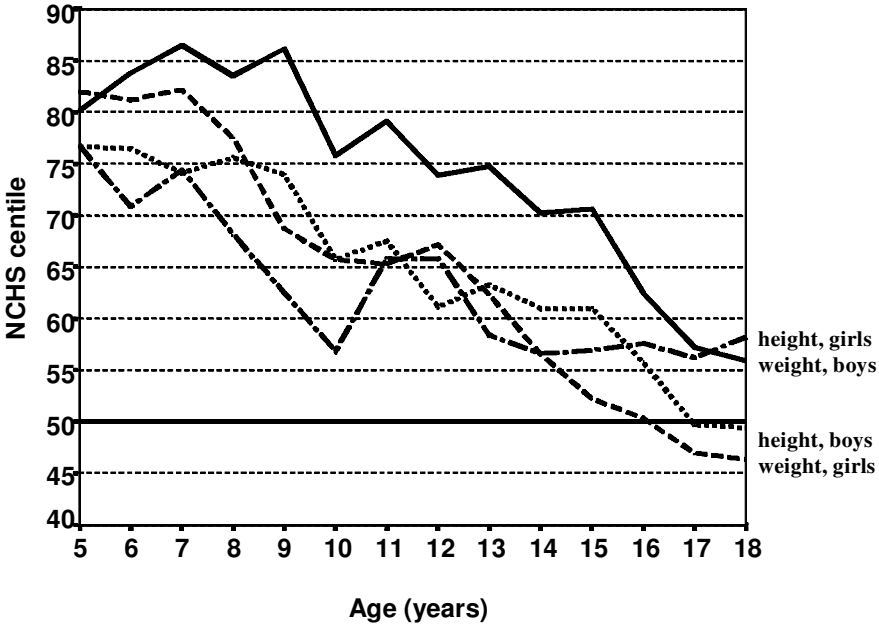

Figure 5. Brazilian mean values of weight and height for age expressed as centiles of the NCHS/WHO standard.

4. Discussion

The present study reveals a sharp positive trend in growth of the middle and upper class juvenile and adolescent population of European ancestry living in the most industrialized region of Brazil. At the age of 18 years, the rates at which the process is occurring, especially for male weight (4.41 kg per decade) and female height (2.5 cm per decade), are among the highest reported so far. Positive trends in male heights (1.91 cm per decade) and female weight (1.39 per decade) are also high. The best comparative basis for this study is the survey done in Venezuela (Lopez-Contreras Blanco, Landaeta-Gimenez and Mendez-Castellano 1989), a country that shares with Brazil both an intense economic growth in the last century and the ethnic background of the population. The Brazilian results are slightly above those obtained by the Projeto Venezuela: Carabobo State, which covered the 10 years from 1978 to 1987 and revealed impressive positive trends in the white urban population (Lopez Blanco 1995). Also in common with the Venezuelan survey is the fact that trends are maximal at the beginning of puberty (with the exception of female height in our study), suggesting a trend towards earlier maturation times.

It must be noted that though high rates of increase in weight and height are shared with other developing economies like Hong Kong, Taiwan and China (Eveleth and Tanner 1990), only the Brazilian sample among these has reached mean values of anthropometrical measurements comparable, or even above the NCHS/WHO reference values. We interpret this as resulting from the fact that this sample of Brazilians is not only healthy and well-nourished, but also of European ancestry. The data presented in this study suggest that, at least in this population from the city of São Paulo (and supposedly other urban and well-off populations of European ancestry in the country), average weights and heights may be far from reaching a plateau in the 1990s.

However, this study reveals some differences between the Brazilian and the NCHS/WHO curves. While adult values of weight and height are similar in the two populations, Brazilian subjects before adolescence occupy extremely high percentiles of the standard curves, and then a continuous decrease occurs as they enter the adolescent period. This relative reduction in growth rates is more intense for male height and female weight (eventually reaching values below the 50th percentile at 18 years). For this reason, the shape of adult males and females differs in a comparison with the international standard: men are relatively heavy, women are relatively lean. The analyses reinforce an almost general perception that growth deficits in relation to the NCHS should not always be interpreted as the outcome of nutritional deficits. Two points should be considered regarding the above results. First, in relation to the differences between the younger Brazilian children and NCHS values, a number of factors besides population differences in growth may contribute to the observed pattern. Among these, age assessments and, particularly, differentials in the position of adolescent growth spurt, could be responsible. Secondly, it should be noted that the comparison of recent anthropometric studies to the NCHS values are doing so across generations, and that current American children and adolescents would most probably differ significantly from the NCHS averages.

Because of the diversity of socio-economic conditions and ethnic backgrounds that characterize Brazilian populations, the results presented here clearly do not apply to the country as a whole. However, some factors suggest that the process may not be exclusive to this better-off sample. Previous studies covering the period from the early 1950s to the early 1980s (reviewed and analysed by Monteiro *et al.* 1994) show the occurrence of consistent positive trends in all the regions of the country and in different socio-economic groups. The process of economic growth in Brazil during the second half of this century seems to have been at least partially reflected in an improvement on social welfare. After a decade of relative economic stagnation in the 1980s (Monteiro *et al.* 1994), Brazil has returned to a path of improvement on public services and living conditions in the current decade, evidenced by a positive variation in social indicators in the period from early 1980s to late 1990s (table 4).

Factors like access to sanitation and clean water are widely believed to affect directly growth patterns, while others, such as number of physicians per 10 000 inhabitants have an impact that is more difficult to evaluate given the very unequal wealth distribution across Brazil. Such indirect arguments cannot substitute for concrete data, and for this reason the results of this survey stress the need for further anthropometric studies in the country, with the aim of investigating if and how Brazilian populations from lower social strata are responding to social and economic

Table 4. Evolution of some social indicators in Brazil from early 1980s to middle and late 1990s. Sources: World Bank (1999).

Urban population (%)	66 (1980)	80 (1998)
Access to safe water (%)	53.2 (1980)	72 (1995)
Access to sanitation (%)	41.5 (1980)	73 (1993)
Infant mortality rate per 1000 live births	70 (1980)	34 (1997)
Life expectancy at birth	64 (1982)	67 (1996)
Physicians per 10 000 inhabitants	7.7 (1981)	13.4 (1997)

change. But as far as the well-off people from São Paulo are concerned, industrialization, urbanization and increase in per capita income are producing beneficial effects on growth.

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Zusammenfassung. *Zielsetzung*: In diesem Artikel wird ein signifikanter säkularer Trend bei der Körperhöhe und dem Körpergewicht in einer städtischen brasilianischen Population beschrieben und diskutiert.
Methodik: Anthropologische Messungen bei 7878 Kindern und Jugendlichen von Sao Paulo, Brasilien, welche 1997/98 durchgeführt wurden, werden mit Daten einer früheren Studie aus dem Jahr 1978 verglichen. Beide Stichproben umfassen Kinder von städtischen Mittelklassefamilien europäischer Abstammung.
Hauptbefunde und Ergebnisse: Die Vergleiche zwischen den beiden Stichproben zeigen stark positive säkulare Trends bei der Körperhöhe und dem Körpergewicht. Außerdem weist die Stichprobe von 1997/98 keine Wachstumsdefizite verglichen mit der internationalen WHO/NCHS Referenz auf.
Schlußfolgerungen: Der positive Trend kann als das Resultat der ökonomischen Entwicklung und der Verbesserung sozialer Indikatoren erklärt werden, während das Fehlen von Wachstumsdefiziten, im Gegensatz zu den Befunden anderer Studien, die in Entwicklungsländern durchgeführt werden, eine Folge der gemeinsamen genetischen Basis der brasilianischen Stichprobe wie auch der US-Stichprobe, welche der NCHS/WHO Referenz zugrunde liegt, ist.

Résumé. *Objectif premier*: Cet article décrit et discute l'évolution séculaire significative de la stature et du poids d'une population urbaine du Brésil.
Méthode: Des mensurations anthropométriques de 7878 enfants et adolescents brésiliens de Sao Paulo obtenues en 1997/98 sont comparées avec des données d'une étude antérieure effectuée en 1978. Les deux échantillons sont constitués à partir de familles urbaines de classe moyenne et d'origine européenne.
Principaux résultats: Les comparaisons entre les deux échantillons révèlent l'existence d'une forte tendance séculaire affectant la stature et le poids. De plus, l'échantillon de 1997/98 ne montre pas de déficit de croissance par rapport aux références internationales de l'OMS/NCHS.
Conclusions: La tendance séculaire à l'accroissement peut être expliquée par l'amélioration des indicateurs sociaux et par le développement économique. L'absence de déficits de croissance, contrairement à ce qui est décrit dans d'autres études effectuées dans les pays en développement, provient du partage d'un même fond génétique par l'échantillon brésilien étudié et par l'échantillon américain qui est à la base de la référence OMS/NCHS.