

Original Research Article

Secular Changes in Body Height and Weight of Portuguese Boys Over One Century

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ABSTRACT This study examines secular changes in attained height and weight in student boys from a military boarding school (*Colégio Militar*) in Lisbon, Portugal. Data for 1899–1906, 1929–1936, 1961–1966, and 1999–2006 obtained from the archives and medical files of the *Colégio Militar* were used in this study. In a century Portuguese boys increased in height by 10.5 cm at age 10 to 19.1 cm at age 14, at a mean increase of 1.54 cm per decade. The gain in weight was between 8.7 and 18.9 kg for 10- and 14-year-old boys, respectively, at a mean increase of 1.54 kg per decade. In the same period, age at peak height and weight velocity advanced ~ 2 years, showing an acceleration of developmental tempo. However, most of the real gain in height and weight and the decrease in pubertal age occurred after 1961–1966. This mirrors major improvements in social and economic conditions that initiated in Portugal in the 1960s, and then by political events in the 1970s that promoted further progress. *Am. J. Hum. Biol.* 20:270–277, 2008. © 2008 Wiley-Liss, Inc.

During the 19th and 20th century a remarkable increase in mean height and earlier maturation has been observed in almost all European countries (Bodzsar and Susanne, 1998; Susanne et al., 2001). This has occurred as a consequence of social and economic transformations brought by industrialization and increased urbanization, but especially by social, economic, and political changes that took place after World War II. However, this secular trend towards an increase in mean height and earlier maturation has not occurred in all countries at the same time. In general, northern Europe experienced changes in body size and maturation of children and adolescents earlier than southern Europe (Susanne et al., 2001). During most of the 20th century, Portugal experienced a period of economic stagnation and a long dictatorship, with a late and weak industrialisation, access to market economies only in the 1960s, the end of the dictatorship in 1974 and economic integration with the European Community in 1986. As a reflection of these changes, patterns of growth and development in Portugal remained relatively unchanged for most of the 20th century and experienced very recent modifications. Padez (2002), for example, showed that the greatest increment in stature of Portuguese conscripts occurred after 1970, which results from the greatest increase in mean stature of individuals who were born in the 1960s and later. Similarly, Padez (2003) has shown that the greatest reduction in age at menarche has occurred in girls that were born in the 1970s.

Portugal lacks long series of childhood growth data to analyze secular trends, although conscript adult data have been used for some time to illustrate long trends in physical growth of the Portuguese (Castro et al., 1998; Padez, 2002; Padez and Johnston, 1999; Sobral, 1990). Explorations of Portuguese secular trends in child height and weight have also only provided limited temporal information (Caninas, 2002; Mota, 1990; Rosa, 1983; Varela-Silva and Bogin, 2003). This study examines changes in attained height and weight for student boys from a military school (*Colégio Militar*) in Lisbon, and for the first time, it is possible to examine secular changes in child growth over a 100 year period in Portugal. Although data are restricted to males, it is the century-long series of Portuguese growth data available from a single source. Since

the structure of the student population at the *Colégio Militar* is similar across the different cohorts of boys, they are comparable over time. These are important concerns when examining secular changes in growth (Cernerud and Lindgren 1991, Zellner et al., 1996). In this study, it is hypothesized that major changes in height and weight of Portuguese children only occurred after the 1960s. This is a late change compared to other European countries, but it reflects the particularities of Portuguese political, economical and social history.

SOCIAL AND ECONOMIC CHANGES IN PORTUGAL

Portugal remained a very isolated and underdeveloped society for most of the 20th century. The country emerged from the 19th century as a declining world political power, with a late and incomplete industrialization, a heavy primary sector based on a poor and rudimentary agriculture with polarized and unequal land distribution, an insufficient penetration of market mechanisms, and an overwhelming presence of the state. Portugal was also a country with deep social inequalities, where a small elite owned most of the wealth and a middle class was mostly absent. Social relations were also very conservative and stemmed from traditional spheres of the family and of the Catholic Church. Despite some initial promises of modernization from liberal movements in the early 19th century, the establishment of a republican state in Portugal in 1910 and then the rise of a dictatorship in 1926 established a strong and repressive state which, together with the absence of egalitarian and democratic traditions, reinforced the closed nature of the country. Portuguese per capita income was one of the lowest in Europe, living con-

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ditions were very poor, and infant mortality rates were very high. It was not until 1974 that a military coup overthrew the dictatorship and set the basis for a democratic system (Baiôa et al., 2003) that accomplished improvements in economic and social welfare. In 1986 Portugal became a member of the European Economic Community, an event that brought further progress with the consolidation of social organization models and major improvements in basic infrastructures. However, Portugal experienced the first significant economic and social changes during the dictatorship in 1960 with the country's union with the EFTA (European Free Trade Association), which opened the Portuguese economic market to Europe, stimulated capitalist trade and liberalization of domestic prices, and foreign investment (Corkill, 2003). Later in 1968, some of the liberal reforms carried out by the dictator's successor, promised further economic and social progress, namely in terms of increasing the coverage of health care and social security to the population. To this we can add cultural and social changes brought by the heavy emigration and urbanization of the 1960s, by the increasing access to information and wide exchange of political and cultural ideas diffused by ampler mass media, particularly the television, and the broad social discontent caused by the Portuguese colonial wars (Barreto, 1996).

Portugal, therefore, did not experience major social and economic changes after World War II like other European countries. The country adopted a neutral position during the war and the dictatorship represented a long period of economic stagnation. Portugal, like any other society, was never unchanged, but instead changes were occurring at an unbearable slow rate. In just a few decades, however, Portugal accomplished what other countries took considerably more time to achieve. To illustrate these changes over time, data from a few social, economic, demographic and health indicators were compiled and are shown in Table 1. The choice of indicators was based on the availability of data that could provide the longest trends over the 20th century.

In 1900, the Portuguese population was ~5.5 million people, but increased slowly until 1960, when it decreased and became stagnant by 1970 when there were more than 8.5 million people (Veiga et al., 2004). Since then the increase has been practically non-existent and achieved, almost exclusively, at the costs of immigration. This stagnation is a reflection of decreased fertility (Table 1) since the early 20th century. Between 1940 and 1960, the average fertility rate remained stable and it was only in the 1970s that the fertility of Portuguese women decreased by 25%. Since the 1980s the country ceased to guarantee generational continuity, given that 2.1 births per woman is considered the minimum required to replace the existing population. The 1970s and 1980s also witnessed a major change in labour force structure (Table 1). Portugal not only had a slow and late rate of decline in the number of agriculture workers but very high percentages were reached for the service sector without prior peaks of employment in industry. The lack of industrial jobs in most of the cities meant that the rural population either enlarged the positions of an unproductive service sector or emigrated (Sapelli, 1995). More than 2 million Portuguese emigrated between 1930 and 1970, of which almost half of them in the 1960s (Barreto, 2000). Another major change in the Portuguese labour force was the beginning of the liberation of women and their open access to the labour market the 1960s (Barreto, 1996).

TABLE 1. Evolution of some socioeconomic, demographic and health indicators in Portugal between 1900 and 2000

Indicator/year	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000
Population in the agricultural sector ^a	-	57.4	-	48.2	51.4	49.4	43.3	39.7	19.4	10.8	5.0
Population in the industrial sector ^a	-	21.5	-	17.3	19.7	23.8	28.7	40.0	38.8	37.9	35.1
Population in the services sector ^a	-	21.1	-	35.4	28.9	26.8	28.0	20.3	41.8	51.3	59.9
Per capita GDP ^b	1,302.0	1,228.0	1,229.0	1,571.0	1,615.0	2,086.0	2,956.0	5,473.0	8,044.0	10,826.0	14,022.0
Public expenditure on health ^c	-	-	-	-	-	0.5 ^f	0.8	1.6	3.7	4.2	4.7 ^g
Social security beneficiaries ^d	-	-	-	-	-	-	34.9	73.3	86.9	82.4	85.2 ^h
Adult literacy rate ^e	22.0	25.0	33.0	41.0	48.0	56.0	62.0	71.0	78.0	89.0	91.0
Fertility rate ^f	-	-	-	3.9	3.2	3.2	3.2	3.0	2.2	1.5	1.5 ^k
Infant mortality rate ^g	-	133.8	164.1	143.6	126.1	94.1	77.5	58.0	24.3	10.9	5.5
Post-neonatal mortality rate ^h	-	-	-	95.5	87.5	62.9	46.8	31.9	10.5	3.3	2.1
Life expectancy at birth - women ⁱ	-	-	40.0	49.2	52.8	60.5	66.4	70.8	76.7	77.3	79.4
Life expectancy at birth - men ⁱ	-	-	35.8	44.8	48.6	55.5	60.7	64.2	69.1	70.2	72.4

^aPercent of active population. Sources: Cabral (1979), Barreto (2000) and INE (2002b).

^b1990 international Geary-Khamis dollars. Source: Maddison (2003).

^cPercent of GDP. Sources: Lobo (2000) and Eurostat (2000).

^dPercent of active population. Source: Barreto (2000).

^ePercent of the adult population. Sources: Tortella (1994) and INE (1996, 2002b).

^fAverage number of livebirths per woman surviving the childbearing ages (15-49 years). Source: Barreto (2000).

^gDeaths, from birth to one year for every 1,000 live births. Sources: Valério (2001) and INE (2002a).

^hDeaths, from one month to one year for every 1,000 live births. Sources: Barreto (2000) and INE (2002a).

ⁱAge in years. Sources: Valério (2001) and INE (2002b).

^jData is for 1954.

^kData is for 1997.

TABLE 2. Evolution of consumption of different food types in Portugal between 1950 and 2000

	1950 ^a	1960 ^b	1970	1980	1990	2000
Vegetable products	2091.00 (87.9)	2,127.59 (86.0)	2,554.97 (85.1)	2,286.13 (82.1)	2,648.81 (77.0)	2,665.74 (71.3)
Cereals	1,072.00 (48.4)	1,026.03 (41.5)	1,165.45 (38.8)	969.18 (34.8)	987.19 (28.7)	1,046.51 (28.0)
Starchy roots	213.00 (8.9)	165.57 (6.7)	204.02 (6.8)	174.78 (6.3)	252.11 (7.3)	223.06 (6.0)
Sugar	131.00 (5.5)	180.80 (7.3)	261.31 (8.7)	261.49 (9.4)	291.47 (8.5)	295.81 (7.9)
Animal products	288.20 (12.1)	345.65 (14.0)	447.02 (14.9)	499.42 (17.9)	792.44 (23.0)	1,075.49 (28.7)
Fish and seafood	57.00 (2.4)	71.44 (2.9)	79.76 (2.7)	47.13 (1.7)	84.43 (2.5)	82.95 (2.2)
Meat	94.20 (3.9)	99.62 (4.0)	153.03 (5.1)	202.86 (7.3)	293.83 (8.5)	405.42 (10.8)
Animal fats	88.00 (3.7)	64.80 (2.6)	71.03 (2.4)	85.42 (3.1)	164.24 (4.8)	238.22 (6.4)
Milk	21.00 (0.9)	88.97 (3.6)	119.39 (4.0)	132.73 (4.8)	207.65 (6.0)	292.13 (7.8)
Total cal/day	2,379.00	2,473.24	3,002.00	2,785.56	3,441.25	3,741.23

Source: Faostat (2007). Values are in estimated total per capita daily energy intake (calories/day) and in brackets percent of daily intake.

^aData is for 1948/1949. Source: INE (1951).

^bData is for 1961.

In the period between 1960 and 1970 also rested the largest relative increase in per capita income and initiated the exponential growth of the economy (Table 1). Compared to the rest of Western Europe, however, Portugal showed the latest increase in per capita GDP (Tortella, 1994). In parallel with the increase in per capita income is the twofold increase in public expenditures on health and in social security coverage. Changes in public expenditure on health are enormous and the rates of growth are 100% between 1960 and 1970, and 131%, between 1970 and 1980. After 1990 the growth in public expenditure on health levels off. Massive changes in social security coverage are also self-evident. The constitution of 1933, approved under the dictatorship, included the promotion and support of private social assistance institutions but not the creation of a state financed national social security or health system (Cardoso and Rocha, 2002). This implied an absent welfare state whose only responsibilities were to frame and supervise the private system. Only the urban working class had limited welfare coverage from private insurance companies and professional associations and the countryside effectively did not receive benefits. In the 1960s, some of the first steps toward a modern state-run welfare system in Portugal were taken, but it was only during the 1970s that public health and social welfare programs were established and later successfully implemented (Veiga et al., 2004).

Adult literacy rates are no exception to the changes that were taking place, although they seem to occur at a slower rate. In 1900 around 80% of the Portuguese population was not able to read or write, and it took almost 100 years to reverse the proportion and achieve 90% of literate adults. It is no surprise that literacy was kept at low rates during the dictatorship, given that mandatory school was reduced by the regime to 4 years (later further reduced for girls to 3 years), a situation that was maintained until 1960 (Neves and Calado, 2001). Only in 1986 was mandatory school attendance extended to 9 years (Barreto, 1996).

Given the social and economic history of Portugal, it is no surprise that health conditions were long among the poorest in Western Europe and only showed major improvements since the 1970s. The greatest relative declines in both infant (58%) and post-neonatal mortality (67%) occurred between 1970–1980 and 1980–1990 (55% and 69%), possibly reflecting the consolidation of the Portuguese health care system, which by 1975 had created 266 local health centres to provide universal free health care for the whole population but particularly for infants and children (Palminha et al., 1997). Although changes in

life expectancy (the greatest relative increase occurred in the 1930s) have not been totally synchronic with changes in infant mortality rates, it has been steadily increasing until 1990, when it seems to have levelled-off.

Another important expression of these rapid changes can be found in Portuguese nutritional trends. Table 2 shows the per capita total daily energy intake and percent of daily intake of some food products in Portugal. Although these rates of food consumption provide important information about the nutrition of the Portuguese they are just crude measures of nutritional factors and are at the most indicators of quantity rather than quality of diet. Between 1950 and 2000 the total daily intake of calories increased over 1,000 calories. All food types showed an increase in absolute intake, but more noticeable in animal products than in vegetable foods. Given that the total daily intake of calories also increased, the percent of daily calorie consumption animal food products (particularly meat and animal fats) was greatest between 1970 and 1980 (17%), but especially between 1980 and 1990 (22%). At the same time the percent of daily caloric intake of vegetal products showed its greatest decrease, particularly of cereals (–21%). However, an important increase in animal products and decrease in cereal consumption had already occurred between 1950 and 1960. Of noticeable importance during this earlier period is also milk intake. Between 1950 and 1960 there was a threefold increase in absolute or relative milk consumption. Only meat showed similar increases in consumption between 1970 and 1980, but never as high as that of milk. Towards the end of the 20th century, milk and animal fats, showed remarkable increases in percent of daily consumption.

MATERIAL AND METHODS

The samples

The core samples of growth data used in this study derive from the *Colégio Militar*. This is a military boarding school located in Lisbon that was founded in 1803 and its prime purpose has been to provide education to the sons of military officers. It is a preparatory, secondary, military, and residential school for boys and young men between the ages of 10 and 17 (Matos, 2003). Admissions to the *Colégio Militar* follow strict regulations. Priority is given to sons of military officers, particularly sons of those who have been killed or incapacitated in combat. Although sons of civilians have also been allowed, their admission has been very limited and restricted to wealthier segments of the population, such as the sons of the ar-

istocracy or of the upper classes. Boys were also selected on the basis of a series of academic and health examinations. Since most of the boys were sons of the military, all officer ranks of the armed forces are represented. As such, *Colégio Militar* boys are mostly representative of middle to high socioeconomic strata. Sons of sergeants or corporals were not considered suitable for the *Colégio Militar* and in 1911 another military school (*Instituto dos Púlpilos do Exército*) was founded to provide education for these children. Therefore, boys were selected, not only on the basis of their physical development and overall health status, but also on the basis of their social strata. The boys originate from all regions of Portugal, but most come from Lisbon and its surroundings. Besides formal education, the *Colégio Militar* also provides accommodation, meals, health care and an active environment. In this study, it is assumed that there is a positive correlation between the overall socioeconomic development of Portugal and the changes in the specific environment of the cadets.

Height and weight data

Height and weight data of boys between the ages of 10 and 17 were collected from the *Colégio Militar* archive and medical files. The following four periods of years were selected for the collection of data: 1899 to 1906 (*Colégio Militar*, 1902, 1903, 1904, 1905, 1906, 1907a,b), 1929 to 1936 (*Colégio Militar*, 1930, 1934, 1938, 1939a,b), 1961 to 1966 (*Colégio Militar*, 1964a,b, 1965, 1966, 1967, 1968), and 1999 to 2006. Data from the first to the third period are available in the *Anuários do Colégio Militar*, a school's annual publication, whereas data from the fourth period were obtained directly from the medical files of the current students enrolled. The combination of data of several years into a single period was justified due to relatively small sample sizes for each year. Height and weight data for *Colégio Militar* boys were published annually between 1899–1900 and 1913–1914 and then became progressively more cursory until 1965–1966, when they were last published. Between 1965–1966 and 1998–1999 there are no records of height or weight. The first three periods were selected on the basis of availability of data and to allow for an ~25–30-year interval between each period. Since most boys are re-measured annually during their stay in school, samples are made of mixed-longitudinal data, where the same cohort provides data for different ages. In total, 6,986 records of height and weight were computed and mean sample sizes for each age group varied from a maximum of 493 to a minimum of 18, at a mean of 233.

Enrolment in the *Colégio Militar* was subjected to minimum height and weight requirements. This was only a requisite for admission of 10- to 11-year-old boys, although older children were also accepted. Because minimum height and weight requirements were not the sole criteria for admission, this permitted some flexibility in admission, and there is no indication that short height and low weight in subsequent years (>11 years-old) were reasons for boys to be excluded from the *Colégio Militar*. Minimum height and weight requirements have changed at least once (1962) since the early 20th century. The measurements of the boys' height and weight were done by the school nurses. The boys were measured twice a year, once in the spring and once in the fall, but only the fall measurements were considered. Because of the large gap between 1961–1966 and 1999–2006, height and weight

averages were compared to cross-sectional data published by Alves et al. (1980) and collected from 9- to 17-year-old boys enrolled in randomly selected public schools of the city of Lisbon in 1977–1978. All data were also compared to national averages of height and weight obtained from the only Portuguese national mixed-longitudinal growth survey carried out between 1971 and 1981 (Rosa, 1983).

Analytical procedure

Height and weight growth profiles were computed using simple averages at each age for each of the five periods (1899–1906, 1929–1936, 1961–1966, 1977–1978, and 1999–2006) and compared to assess secular changes. Growth velocity curves were estimated from differences in mean height and weight between ages, because individual raw data were not available for all years. Velocity curves between the five periods were compared to assess differences in age at peak height velocity and used as an indirect estimate for tempo of growth and the onset of pubertal development. Pubertal growth velocity appears attenuated in population velocity curves estimated from differences in means between annual cohorts, when compared to individual growth velocity curves (Falkner and Tanner, 1986; Zemel and Johnston, 1994). Because most of the data are mixed-longitudinal the attenuation of pubertal growth velocity is likely to be less attenuated. Nevertheless, Zemel and Johnston (1994) have shown that velocity curves can be accurately estimated using cross-sectional data. Although all of the *Colégio Militar* samples are truncated on the left side of height and weight distributions, because raw data were not available for all of the samples, truncated regression could not be used to estimate true height and weight trends. However, since most samples are homogeneous over time and only truncated at younger ages (10- to 11-year-old), the overall tendency in height and weight is not likely to be too affected.

Mean increments in height and weight over same age cohorts of consecutive periods were also calculated. Because each time period is separated by unequal temporal distances, height and weight increments between cohorts were converted in centimetres per decade and kilograms per decade, respectively. For calculating the height and weight gains per decade the midpoint in each period was considered (e.g. in the period between 1899 and 1906, the midpoint is 1902.5).

RESULTS

Mean height and weight for the four samples of *Colégio Militar* boys measured in 1899–1906, 1929–1936, 1961–1966, and 1999–2006, are illustrated in Figures 1 and 2, together with the same data for Lisbon public schoolboys measured in 1977–1978 (Alves et al., 1980) and national averages for 1971–1981 (Rosa, 1983). Temporal changes in mean height and weight show a continuing positive secular trend in body size. Changes between 1899–1906 and 1961–1966 are small, but afterwards the trend is more pronounced. Height and weight graphs are analogous and show the same overall tendency, but changes seem more noticeable in weight. In both Figures it is clear that data from the national growth survey (Rosa, 1983) shows that national averages of height and weight are behind averages of *Colégio Militar* boys, who by 1961–1966 were already as tall and as heavy as national samples 10 years later.

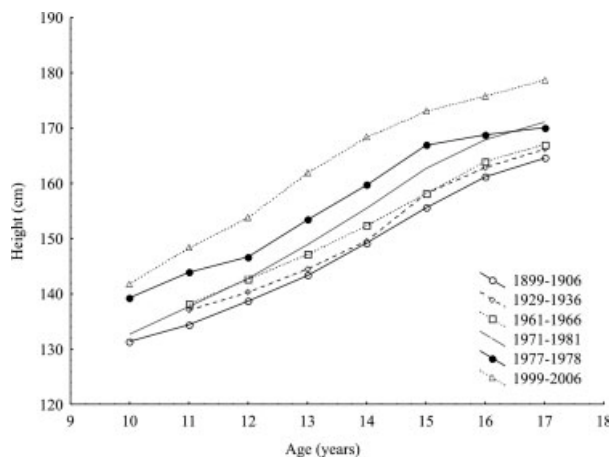


Fig. 1. Secular changes in body height (cm) of *Colégio Militar* boys measured between 1899–1906 and 1999–2006. Data for boys measured in 1977–1978 are from Alves et al. (1980) and for boys measured in 1971–1981 are from Rosa (1983).

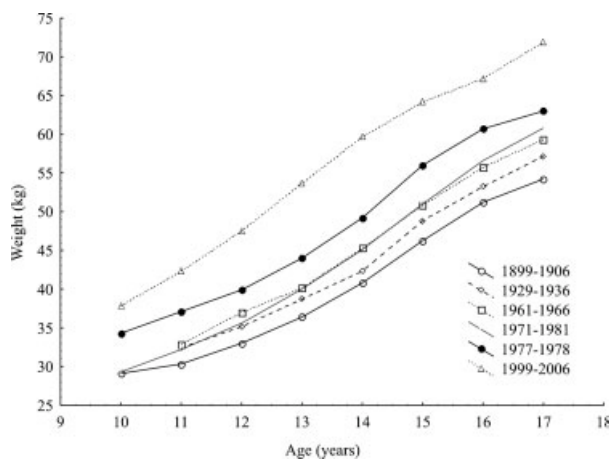


Fig. 2. Secular changes in body weight (kg) of *Colégio Militar* boys measured between 1899–1906 and 1999–2006. Data for boys measured in 1977–1978 are from Alves et al. (1980) and for boys measured in 1971–1981 are from Rosa (1983).

Height and weight velocity curves for the six samples are shown in Figures 3 and 4, respectively. Peak height and weight velocity occurs progressively at younger ages from 1899–1906 to 1999–2006, indicating a faster tempo of growth over time. Age at peak height velocity did not change significantly between 1899–1906 and 1961–1966. During this time period peak height velocity occurred at ~14–15 years of age. The age at peak velocity is not well determined in the 1977–1978 sample. In this sample there are two peak increments in height separated by and inflexion of the velocity profile. This may suggest, however, that peak height velocity may have accelerated approximately one year between 1961–1966 and 1977–1978, since it seems to have occurred at 13–14 years, the mid-point between the two peak height increments in 1977–1978. In 1999–2006 peak height velocity occurred at even younger age than the previous period (12–13 years). This period also showed the greatest height increment at

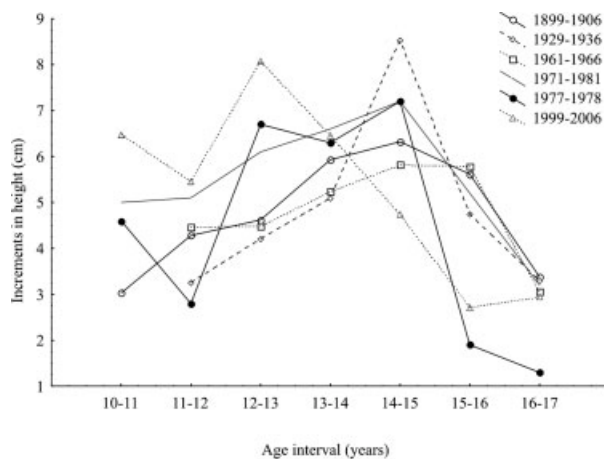


Fig. 3. Secular changes in body height velocity (cm/decade) of *Colégio Militar* boys measured between 1899–1906 and 1999–2006. Data for boys measured in 1977–1978 are from Alves et al. (1980) and for boys measured in 1971–1981 are from Rosa (1983).

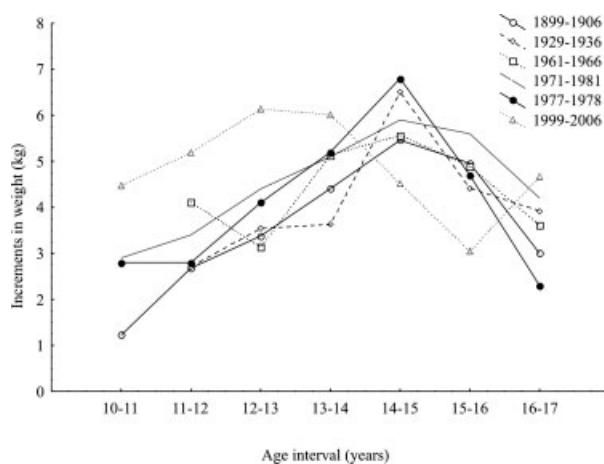


Fig. 4. Secular changes in body weight velocity (kg/decade) of *Colégio Militar* boys measured between 1899–1906 and 1999–2006. Data for boys measured in 1977–1978 are from Alves et al. (1980) and for boys measured in 1971–1981 are from Rosa (1983).

peak height velocity (8.1 cm), except that in the 1929–1936 period. Changes in age at peak weight velocity are somewhat analogous to those of peak height velocity, albeit slightly delayed. Age at peak weight velocity does not change significantly between 1899–1906 and 1961–1966 (14–15 years) and then it shows a very significant advancement in 1999–2006 (12–13 years). Between 1961–1966 and 1999–2006 peak weight velocity accelerates ~2 years. Velocity curves based on the national growth survey data show that by 1971–1981 national samples had not yet showed a significant acceleration in tempo of growth compared to earlier data.

Table 3 shows the secular changes in height and weight as increments per decade between cohorts of the four *Colégio Militar* samples and then between the earliest and latest period. In about a century, between 1899–1906 and 1999–2006, height increased 1.05–1.91 cm (mean of 1.54) per decade and weight increased 0.87

TABLE 3. Height and weight increments of Colégio Militar boys between two consecutive periods, and between the earliest and latest period

Age	1899–1906 to 1929–1936		1929–1936 to 1961–1966		1961–1966 to 1999–2006		1899–1906 to 1999–2006	
	Height	Weight	Height	Weight	Height	Weight	Height	Weight
10	–	–	–	–	–	–	1.05 (10.5)	0.87 (8.7)
11	0.87 (2.6)	0.70 (2.1)	0.39 (1.2)	0.16 (0.5)	2.59 (10.1)	2.41 (9.4)	1.39 (13.9)	1.20 (12.0)
12	0.53 (1.6)	0.73 (2.2)	0.77 (2.4)	0.58 (1.8)	2.85 (11.1)	2.69 (10.5)	1.51 (15.1)	1.45 (14.5)
13	0.40 (1.2)	0.77 (2.3)	0.87 (2.7)	0.45 (1.4)	3.77 (14.7)	3.46 (13.5)	1.86 (18.6)	1.72 (17.2)
14	0.13 (0.4)	0.50 (1.5)	0.90 (2.8)	0.97 (3.0)	4.08 (15.9)	3.69 (14.4)	1.91 (19.1)	1.89 (18.9)
15	0.83 (2.5)	0.83 (2.5)	0.03 (0.1)	0.65 (2.0)	3.82 (14.9)	3.44 (13.4)	1.75 (17.5)	1.79 (17.9)
16	0.57 (1.7)	0.67 (2.0)	0.35 (1.1)	0.81 (2.5)	3.03 (11.8)	2.95 (11.5)	1.46 (14.6)	1.60 (16.0)
17	0.53 (1.6)	1.00 (3.0)	0.29 (0.9)	0.68 (2.1)	2.97 (11.6)	3.23 (12.6)	1.41 (14.1)	1.77 (17.7)
Mean	0.55 (1.6)	0.74 (2.2)	0.51 (1.6)	0.61 (1.9)	3.30 (12.9)	3.12 (12.2)	1.54 (15.4)	1.54 (15.4)

Age is in years, height increments are in centimetres per decade and weight increments in kilograms per decade. Values in brackets are absolute increments in height (cm) and weight (kg). Mean increments when all ages are pooled are also shown.

to 1.89 kg (mean of 1.54) per decade. However, the greatest increments in height (2.59 to 4.08 cm/decade) and weight (2.41 to 3.60 kg/decade) occurred between 1961–1966 and 1999–2006. Between 1899–1906 and 1961–1966 increments have not been very significant, always below 1 cm and 1 kg per decade. Around 84% of the height and 79% of the weight gained in the last 100 years, occurred after 1961–1966.

DISCUSSION

An insight over secular change in childhood growth of Portuguese boys was possible for the first time. Data in this study show clearly a secular trend toward increased height and weight at all ages, and an acceleration in pubertal growth spurt of *Colégio Militar* boys in the last 100 years. Over this period of time two phenomena occurred simultaneously: there was a real gain of definitive stature and a secular growth anticipation trend, which means that boys at all ages became taller and also that young men reached earlier their final adult height (Tanner, 1989). Although *Colégio Militar* boys are not representative of the overall population and are taller and heavier than their national counterparts, their trends of height and weight are clearly correlated with the changes in socioeconomic conditions of the entire Portugal and can be taken as a proxy of the corresponding developments occurred to the overall population. For example, data from Alves et al. (1980) show a very significant increase in height and weight at all ages in 1977–1978, when compared to *Colégio Militar* data from 1961–1966, suggesting that socioeconomic developments that are reflected in trends of height and weight observed in the *Colégio Militar* are also reflected in trends of growth of the overall population. These trends, on the other hand, may not be completely synchronic between the *Colégio Militar* samples and the rest of the population since improvements in living conditions and health tend to affect the higher classes first (Cambois et al., 2001; Haines, 1995; Marmot et al., 1987). This delay is suggested when data from the national mixed-longitudinal growth survey carried out between 1971 and 1981 (Rosa, 1983) are compared with data from the *Colégio Militar* for the period 1961–1966.

Secular trends to increasing childhood height and weight in most European countries have been documented since the late 19th century with the greatest increase occurring right before or after the Second World War (Aubenque and Pineau, 1979; Cameron, 1979; Cernerud and Lindgren, 1991; Fredriks et al., 2000; Krawczynski,

et al., 2003; Ljung et al., 1974; Papadimitriou et al., 2002; Prebeg et al., 1995; Rosique et al., 2001; Sanna et al., 1993; Zellner et al., 1996). Portugal, however, shows a pattern where it was not until some time after World War II that the increase in mean height accelerated. *Colégio Militar* boys experienced the greatest increase in body size after 1961–1966, indicating that the children who were born after the late 1960s and 1970s were the ones who were growing better. Several studies suggest that early life is the critical period where environmental influences have their greatest impact (Cole, 2000; Golden, 1994; Schmidt et al., 1995; Tanner, 1992; Zellner et al., 1996). Therefore, these children were the ones who benefited first from improvements in social and economic conditions that initiated in the 1960s, and then by political changes in the 1970s that promoted further progress and were responsible for further increases in body size. Many of the political, economical and social factors that have been associated with secular trends in height, however, cannot directly affect growth, but must influence growth via biological mediators affecting the ability to optimize nutrition or to acquire pathogens (Schmidt et al., 1995; Susanne et al., 2001).

Dietary changes are among the most important factors in the trend towards more favorable environmental conditions that are rooted in political and socioeconomic changes that occurred in Portugal after 1960. The 1960s witnessed a very rapid increase in per capita GDP (Table 1), reflecting growing incomes of Portuguese families and consequently the increase in access and consumption of basic necessities, such as food. Some of the most important changes in nutrition of the Portuguese since 1950 are seen in consumption of high energy and nutrient rich foods, such as meat or milk (Table 2). Although the consumption of fish has not changed significantly, the increase in meat consumption rose 30% in the 1960s and 43% in the 1970s, illustrating the increasing importance of animal protein in the diet. A very significant increase in total animal protein intake had already occurred in the 1950s with a tendency to increase further after 1970. Compared to most European countries, however, Portugal showed the latest decrease in consumption of crop proteins and latest increased in animal protein consumption (Susanne and Lepage, 1990).

Changes in attained height can also be attributed to changes in environmental quality experienced over the 20th century in Portugal, through changes in exposure to, and treatment of, infectious disease. Of the utmost importance was the universalization of health care. By 1951 the

percentage of the population covered with medical and social services was only 3.9% (Carreira, 1996). By 1960 it had increased to 15.8% and by 1970 to 60% (Carreira, 1996). Since 1976 the state run national health care and social security systems provided medical and social services for virtually all of the population (Veiga et al., 2004). Of particular importance have been vaccination programs against childhood diseases. The Portuguese national vaccine program was initiated in 1965 (Sanches and Carvalho, 1983) and, although immunization against some diseases was already being carried out before 1965, it was until then under mass vaccination, that there was a decreasing trend in the incidence of some of the most common childhood infectious diseases (Gomes et al., 1999; Sanches and Carvalho, 1983). In terms of sanitation, major improvements were also accomplished during this period. For example, in 1960 only 18.6% of the Portuguese households had a bathroom and 41.8% had a toilet (INE, 1964), compared to 58.2% and 79.1% in 1981, respectively (INE, 1984).

No single factor can be associated with the increase in body size of *Colégio Militar* boys. Instead, it is a collective of factors that have contributed to such increase, from improved quantity and quality of nutrition, to lessening of infectious diseases, which were triggered by political, economical, and social changes, that increased family incomes, provided easy access to better nutrition and health care and sanitary living conditions. Data examined during the course of this paper permit the general conclusion that secular changes in body size have been a rather effective monitor of political, economic and social change in Portugal for the past century. Although since Portugal joined the European Economic Community the country has been catching up, judging from the socioeconomic delay that Portugal still has from the rest of more modernized Europe, it is likely that secular trend in body size has not come to a stop.

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