Original Article

THE SECULAR TREND OF GROWTH IN HEIGHT IN BLUMENAU, BRAZIL, AND ITS RELATIONSHIP WITH THE HUMAN DEVELOPMENT INDEX (HDI)

Deisi Maria Vargas,[1*] Luiz Fernando Garcia Lopes Arena,[2] Ana Silveira Soncini[3]

Study conducted at the Department of Medicine, Universidade Regional de Blumenau, Blumenau, SC, Brazil

ABSTRACT

Objective. The objective of this study was to analyze the secular trend of growth in height of military recruits enlisted in Blumenau and correlate it with the HDI index.

Methods. This was a cross-sectional study of recruits aged 18 to 20 enlisted to the 23rd Infantry Battalion in Blumenau between 1963 to 2007. The sample comprised 600 out of a total of 3000 recruits enlisted over the period. Data were collected from individual enlistment files on recruits which had been archived by year. Three years were analyzed from each decade (x3, x5, and x7) and the first forty files were selected systematically from each recruitment year for analysis. Statistical analysis was with descriptive statistics, Student's *t* test and simple linear regression.

Results. There was an increase of the order of 7 cm in the height of recruits in Blumenau over the last 47 years (from 1.7 meters in the 1960s to 1.77 meters in the 2000s) and the increase was most evident between the 1970s and 1980s. The mean heights in years in different decades exhibited a strong and positive correlation with the HDI in Blumenau and Brazil, which both increased progressively during the study period.

Conclusion. The secular tendency in growth in height was positive in Blumenau and had a positive correlation with HDI.

Key words: Growth. Height (stature). Military personnel. Human development.

***Correspondence:**
Rua Antônio da Veiga, 140
- Sala L-002
Victor Konder
Blumenau-SC, Brazil
CEP: 89012-900
Phone: (+ 55 47) 3321-0277
deisivargas@furb.br

Introduction

The term Secular Growth Trend (SGT) describes any change in body size or composition in a given population group over long time periods. Growth velocity and the height attained at different ages are phenotypes that are conditioned by genetic inheritance, to the extent that every person is born with a set potential for growth which is determined by the genotype inherited from their biological parents. However, this potential will only be fully realized if nutritional status is excellent, health status is good and socioeconomic conditions are favorable.[1]

Studies of secular trends in growth are an important tool for analyzing the evolution of the physical health of populations and for highlighting social inequalities between different groups of humans.[2] The most important work on this subject has shown that positive secular growth trends can be attributed, more than anything, to the environmental influences resulting from improvements in sanitary, economic and social conditions. Secular growth trends may reveal a range of different tendencies and growth may be negative, positive or absent.[3] A positive SGT is associated with good living conditions, most notably health and nutrition conditions.[4.]

In Brazil, studies have shown that there was a positive SGT in the final height attained by Navy recruits born between 1940 and 1965 in all five of Brazil's administrative regions and that the increase differs between regions.[5] The increase the final height of the people studied was 0.70 cm per decade for Brazil as a whole, with 0.20 cm per decade in the Northeast region and 1.40 cm per decade in the Mid-West. A study of young people born in São Paulo between 1950 and 1976 found a positive variation of 1.26 cm per decade.[2] Variations in SGT within a single country have also been observed in other developing countries. Studies show that in the most privileged population groups SGT remains positive, in contrast with other groups.[4]

The living conditions of the Brazilian population have been improving significantly over recent decades and this is illustrated by the progressive increase in Brazil's mean HDI over consecutive surveys. In 1960, Brazil's mean HDI was 0.394 and reached 0.757 in 2000 and 0.813 in 2007.[6,7] In the city of Blumenau, the index was 0.674 in 1970 and 0.855 in 2000.[7] This study will describe the secular growth trend in height in the city of Blumenau, with the objective of providing specific regional data on this phenomenon and in order to determine whether the variation in height is correlated with change in mean HDI.

1. Doutora em Pediatria - Professora titular da Universidade Regional de Blumenau, Blumenau, SC
2. Graduando - Acadêmico do curso de Medicina da Universidade Regional de Blumenau, Blumenau, SC
3. Graduanda - Acadêmica do curso de Medicina da Universidade Regional de Blumenau, Blumenau, SC

Methods

This was a cross-sectional study of recruits to the 23rd Infantry Battalion in Blumenau, SC, Brazil, from 1963 to 2007. Since military service is compulsory in Brazil, all young men must report to a Military Service Board during the year of their 18th birthday. The legal implications of failure to report for service mean that enlistment is almost universal among men in this age group. When recruits report to the military board, a military enlistment file is opened and certain phenotypical and sociodemographic characteristics are recorded. The files are archived at the recruiting unit.

At the 23rd Infantry Battalion in Blumenau, SC, the individual files are filed by year of enlistment. The files contain the following information: district of origin, date enlisted at the unit, date and location of birth, height in meters (with decimal precision) and, in some files, educational level. Anthropometry of the recruits was performed using a metal stadiometer fixed to a mechanical balance on which they were weighed (to an accuracy of 100g). Measurements were taken with recruits unshod and in the presence of a physician. This information on anthropometry methods applies from the 1990s onwards (we did not locate information on the measurement procedure in previous decades). Three median years were analyzed from each decade: those ending in 3, 5 and 7. This technique was chosen to avoid sampling data from years close together in time but in different decades, which could lead to false interpretation of the results for those decades (for example: 1959 and 1961). The sample comprised 600 of the total of 3000 recruits, uniformly distributed across the years analyzed (margin of error $< 3.5\%$). The first 40 files for each year to be analyzed were selected systematically. Enlistment files were considered eligible if they related to recruits aged 18 to 20 years who were born and resident in the city of Blumenau.

First the mean height was calculated for each year analyzed (x3, x5 and x7) and then the mean was calculated for each decade (1960s, 1970s, 1980s, 1990s and 2000s). The mean for each decade was then used to calculate a z-score for height, against the *Center for Disease Control* (CDC*)* reference figures.[8] Student's *t* test and simple linear regression were used for statistical analysis, with the significance level set at $p \leq 0.05$. This research was submitted to the Ethics Committee at the *Universidade Regional de Blumenau* under protocol number 018/07 and approved on April 4th, 2007.

Results

The mean height of recruits in the city of Blumenau increased progressively over the study period, by a total of 7 cm in 47 years or 1.4 cm/decade. The increase in height over this period exhibited distinct intensities at different points, with the greatest increment observed for the 1980s, with an increase of 4 cm over the previous decade. During the following decade, between the 1980s and 1990s, no variation was observed in mean height (Table 1).

The simple linear regression equation demonstrated a strong positive correlation between mean height and years and decades ($p < 0.05$), showing a positive linear estimate for the secular growth trend in the study population (Figures 1 and 2).

Mean heights for the years 1973, 1983, 1993 and 2003 were correlated against the HDI figures for the closest available year (1970, 1980, 1990 and 2000) for Brazil and for the city of Blumenau, and a strong, positive and linear correlation was observed for both analyses ($R^2 = 0.992$; $p < 0.005$) (Table 2).

When converted to standard deviations from the mean provided by the CDC reference figures, there was a gain of 1 standard deviation over the study period. The mean height in the 1960s corresponded to -1.04 standard deviations (SD) from the mean for age and sex, rising to -0.89 SD in the 1970s, - 0.28 SD in the 1980s and 1990s and - 0.03 SD during the 2000s.

Discussion

We observed a positive secular growth trend among recruits enlisted in Blumenau over the last 47 years. During this time, mean height increased from 1.70 m in the 1960s to 1.77 m in the 2000s, which is an increase of 7 cm (1.40 cm/decade). This increase in final height may be related to improved living conditions for this population, since we observed a strong correlation between mean height and mean local and national HDI for the decades studied. The greatest variation in stature took place between the 1970s and the 1980s, with a 4 cm increase, which coincides with the period during which the recruits who were reaching their final height had been born during the years of the "Brazilian Economic Miracle" - between 1969 and 1973. Brazil's HDI increased considerably from the 1970s to the 1980s, from 0.674 to 0.797.

Table 1 - Distribution of mean heights in meters (m) by year and decade

Year	Height for year (m)	Height for decade	p*
1963	1.68		
1965	1.68	1.7	--
1967	1.73		
1973	1.7		
1975	1.72	1.71	0.001
1977	1.72		
1983	1.75		
1985	1.75	1.75	0.032
1987	1.75		
1993	1.76		
1995	1.74	1.75	0.637
1997	1.74		
2003	1.77		
2005	1.78	1.77	0.004
2007	1.76		

*According to student's *t* test and against the mean for the previous decade.

Figure 1 - Linear regression correlating mean height (meters) against years analyzed

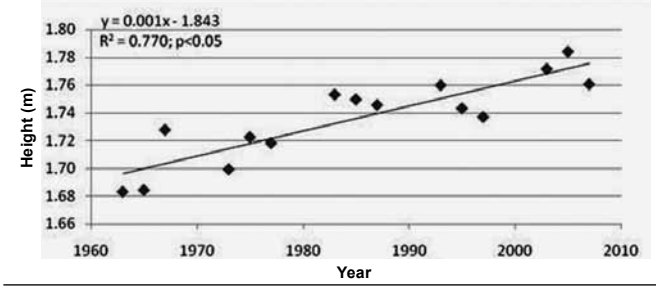

Figure 2 - Linear regression correlating mean height (meters) against years analyzed

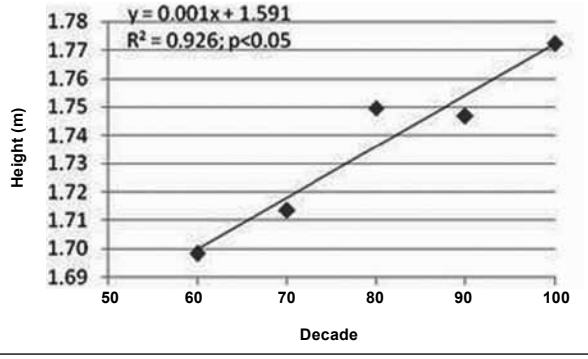

Table 2 - Distribution of mean stature and mean HDI*by year

Year	Height (stature) (m)	HDI** Blumenau	HDI# Brazil
1973	1.7	0.674	0.462
1983	1.75	0.797	0.695
1993	1.76	0.813	0.742
2003	1.77	0.855	0.752

*For the years 1970,1980,1990, and 2000. **Source: SEBRAE-SC, 2005. #Source: UNDP, *Human development report,* 1998.

Several different Brazilian studies conducted in different geographical locations have demonstrated positive SGT in height. Recruits to the Brazilian Navy born between 1940 and 1965 increased in final height by 1.40 cm in 25 years, or 0.56 cm/decade. The increase varied by region, being most intense in the South and Southeast regions (1.20 and 1.80 cm respectively, over the period) and weakest in the Northeast region (0.60 cm over the period).[5] In São Paulo, an increase in final height has been reported of 1.26 cm/decade or 3.42 cm between the 1960s and 1980s. This variation is smaller than the increase in 5 cm detected in final height in Blumenau between these decades. However, as in Blumenau, the greatest increase in stature was observed between the 1970s and the 1980s (2.90 cm/decade in São Paulo and 3.00 cm/decade in Blumenau).[2]

Male adolescents aged 17 to 19 years enlisted to the *Tiro de Guerra* (reserves) in the city of Viçosa in the state of Minas Gerais from 1995 to 2004, exhibited a height increase of 4.00 cm, which is double the 2cm observed in Blumenau between the 1990s and 2000s. A positive association was also observed between educational level and height in addition to a reduction in the prevalence of short stature, from 28% to 11.6%.[9] The variation in stature of young people enlisted to the Army in the state of Pernambuco from the 1970s to the 1990s was 3.70 cm, which is similar to the 4.00 cm variation observed in Blumenau.[10]

Marcondes et al.[11] studied the evolution in the height of people passed fit for military service (Army) between 1979 and 1991 in 24 Brazilian states. The results demonstrated increases in stature in the majority of the states studies. The most impressive increases were observed in the states of Sergipe (4 cm), Minas Gerais (3.90 cm) and Mato Grosso (3 cm). The authors also observed that mean stature, whether in 1979 or in 1991, did not pass the 50th percentile of the reference figures from the United States (National Center for Health Statistics) which is 1.78 m. In Blumenau, mean height at the end of the 1980s also did not exceed the United States standard.

While the majority of studies conducted in Brazil have detected positive SGT in height, one study of cohorts of high socioeconomic status people born in the city of Rio de Janeiro in 1930, 1940, 1950 and 1970 found a variation in final height in 2 cm over 40 years, which did not attain statistical significance when means were compared. Notwithstanding, a positive and significant SGT in height was observed during the prepubescent years, indicating an acceleration in the rate of acquisition of height, which was not reflected in final height.[12] It is probable that individual people will have completed their linear growth earlier, which in young females may have been translated into a reduction in age of menarche.

The variations in magnitude and timing of statural SGT increases in Brazil can be attributed to variations in socioeconomic development in the different regions of the country. Although an HDI is given for Brazil as a whole, the indexes are highly variable depending on geographic location, with figures oscillating between regions, states and municipalities, which have developed differently over the decades.

The phenomenon of positive SGT is not exclusive to Brazil. Over the last 150 years, a progressive trend in increased stature has been observed among people in Western industrialized nations and in developing countries. The mean rates, predominantly relating to European populations, vary depending on age and socioeconomic strata.[13] Studies of the height of recruits in European countries are concentrated between 1960 and 1975 and show considerable increases in mean height over the period, following different patterns in different countries. Dutch recruits exhibited the greatest mean height at the end of this period (1.80 m), followed by Swedish recruits (1.78 m). In these two countries the trend was 1.37 and 0.99 cm/decade. Norway and France are part of an intermediate block with a trend

of 0.88 cm/decade. Trends in the other countries studied were as follows: Belgium (0.74 cm/decade), Italy (0.64 cm/decade) and Denmark (0.53 cm/decade).[14] During the same period, the mean height of recruits in Blumenau varied from 1.70 m in the 1960s to 1.71 m in the 1970s.

During the 1980s, the HDI of the countries listed above were higher than Brazil's HDI: Holland 0.873; Sweden 0.872; Norway 0.877; France 0.863; Belgium 0.861; Italy 0.846 and Denmark 0.876. During the same decade, the HDI for Brazil was 0.685 and Blumenau's HDI was 0.797. In 2000, the HDI in Blumenau reached levels close to those of these European countries, at 0.855; while the HDI for Brazil was 0.750. It is therefore to be expected that, genetic potential permitting, if the HDI of Brazil continues to increased progressively we will continue to observe increases in the final height of Brazilians over the next few decades.

It is interesting that the increased greatest variation in mean height observed between decades coincided with the greatest variation in HDI, both for the municipality and for the nation. Between 1979 and 2005 an increase of 3.2 cm for the period, or 1.2 cm per decade, was observed in the final height of men,[15] which is comparable to Blumenau if one considers that the variation between the 1980s and 2000s was 2 cm or 1 cm/decade. The variation in HDI was also similar: 26.6% in Bluemenau and 22.8 % in China. Another Chinese study, conducted in Shandong province, detected an increase of 4.67 cm in the final height of men at 18 years of age from 1985 to 2005.[16]

A positive SGT in height has also been observed during childhood and adolescence, both in Brazil and in other countries.[17] Monteiro et al. analyzed household surveys from São Paulo covering 22 years (1974 to 1996) and found that 5-year-old children had a mean height that was 2.3 cm greater, corresponding to a 0.650 z-score on the international reference.[1] In Paulínia, SP, when male schoolchildren aged 6 to 12, studied in 1979 and 1980, were compared with children in 1993 and 1994, a positive SGT for height was observed of the order of 1.13 to 5 cm per decade.[4] In the Seychelles, in the Indian Ocean, adolescents aged 15.5 years were compared between 1956 and 2006 (1956 and 1957, 1998 and 1999 and 2005 and 2006) demonstrating a positive SGT. Between the 1950s and 1990s there was an increase in height of 1.62 cm/decade and 1.14cm/decade between the 1990s and 2000s.[18] In Turkey, male schoolchildren aged 7 to 15 years between 1993 and 2003, had increased in stature by 1.7 to 5.5cm/decade.[19] Although the literature demonstrates a worldwide trend towards an increase in the final height of people, there are still reports of negative or absent SGT in height during critical periods. Analyses conducted in Croatia show that SGT in height was absent between 1991 and 2003[20] and negative for children who were aged from 2.5 to 4 years during the war in Croatia.[21]

Conclusions

Summing up, the SGT for height in Blumenau was positive between the end of the twentieth century and the start of the twenty-first, with a strong positive association with HDI. During this period, the mean height of the young men from Blumenau increased 7 cm or 4.1% while HDI increased by approximately 26.6% in Blumenau and 62.0% in Brazil as a whole. Despite the positive SGT, mean height remains below that of developed countries with superior HDI.

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