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Trends in the association between height and socioeconomic indicators in France, 1970–2003

Archana Singh-Manoux[1,2,3], **Julie Gourmelen**[1], **Jane Ferrie**[2], **Karri Silventoinen**[4], **Alice Guéguen**[1], **Silvia Stringhini**[1], **Hermann Nabi**[1], and **Mika Kivimaki**[2]
Archana Singh-Manoux: Archana.Singh-Manoux@inserm.fr

[1] INSERM, U1018, Centre for Research in Epidemiology and Population Health, Hôpital Paul Brousse, Bât 15/16, 16 avenue Paul Vaillant Couturier, 94807 Villejuif Cedex, France, Tel: + 33 177747410; Fax: + 33 177747403 [2] Department of Epidemiology and Public Health, University College London, UK [3] Centre de Gérontologie, Hôpital Ste Périne, AP-HP [4] Population Research Unit, Department of Sociology, University of Helsinki, Finland

Abstract

Average physical stature has increased dramatically during the 20th century in many populations across the world with few exceptions. It remains unclear if social inequalities in height persist despite improvements in living standards in the welfare economies of Western Europe. We examined trends in the association between height and socioeconomic indicators in adults over three decades in France. The data were drawn from the French Decennial Health Surveys: a multistage, stratified, random survey of households, representative of the population, conducted in 1970, 1980, 1991, and 2003. We categorised age into 10-year bands, 25–34, 35–44, 45–54 and 55–64 years. Education and income were the two socioeconomic measures used. The slope index of inequality (SII) was used as a summary index of absolute social inequalities in height. The results show that average height increased over this period; men and women aged 25–34 years were 171.9 and 161.2 cm tall in 1970 and 177.0 and 164.0 cm in 2003. However, education-related inequalities in height remained unchanged over this period and in men were 4.48 cm (1970), 4.71 cm (1980), 5.58 cm (1991) and 4.69 cm (2003), the corresponding figures in women were 2.41, 2.37, 3.14 and 2.96 cm. Income-related inequalities in height were smaller and much attenuated after adjustment for education. These results suggest that in France, social inequalities in adult height in absolute terms have remained unchanged across the three decades under examination.

Keywords

height; trends; social inequalities

1. Introduction

Average height has increased dramatically during the 20th century in many populations across the world with some notable exceptions (Cole, 2003; Moradi, 2010). In Western-European

Correspondence to: Archana Singh-Manoux, Archana.Singh-Manoux@inserm.fr.

countries, the secular trends suggest an increase of about 1 cm in height per decade (Cole, 2000). There are at least two reasons to suggest that socioeconomic factors contribute to differences in height. First, differential economic development is reflected in the mean height of populations; a comparative study on Sweden and Finland shows narrowing height differences between the two countries in parallel with a narrowing of economic differences after the Second World War (Silventoinen *et al.*, 2001). Second, socioeconomic factors within countries have repeatedly been shown to be associated with height (Batty *et al.*, 2009; Cavelaars *et al.*, 2000; Deaton & Arora, 2009; Meyer & Selmer, 1999; Peck & Vagero, 1987; Walker *et al.*, 1988). Childhood socioeconomic conditions influence stature in childhood and adulthood (Billewicz *et al.*, 1983; Bogin & MacVean, 1983; Peck & Vagero, 1987; Rona *et al.*, 1978) and higher adult social position is associated with taller adult height (Cavelaars *et al.*, 2000; Marmot *et al.*, 1984; Meyer & Selmer, 1999; Silventoinen, 2003; Walker *et al.*, 1988). The most important non-genetic factors affecting body height are seen to be nutrition and disease, both of these are socially patterned (Silventoinen, 2003). Another explanation for this association is the discrimination hypothesis, where discrimination against short stature has been suggested as an explanation for lower attained education in a study on 950 000 Swedish men born between 1950–75 (Magnusson *et al.*, 2006).

The association between height and socioeconomic indicators exists also in “officially classless” societies such as the former German Democratic Republic (Komlos & Kriwy, 2002). However, the extent of inequalities remains unclear given the improvements in living standards in the welfare economies of Western Europe. Data on the height of children have been used to support both continuing (Whincup *et al.*, 1988) and diminishing social inequalities (Li & Power, 2004; Liestol & Rosenberg, 1995). Data on adult height are also not conclusive in terms of the trend in height differences as a function of markers of socioeconomic position (SEP). A study on British men born between 1919 and 1939 shows height differences related to SEP to be similar in the younger and the older cohorts (Walker *et al.*, 1988). A European comparative study on adults born between 1920 and 1970 also showed persistent education related differences in height (Cavelaars *et al.*, 2000).

A key issue in the estimation of trends is the changing nature of socioeconomic indicators such as education. As the education levels of populations improve and as fewer and fewer people leave school with no academic qualifications, it becomes meaningless to compare the height of the most and the least educated if this cohort effect has not been taken into account. Thus, estimates of social inequality need to take into account the distribution of the socioeconomic measure. The objective of the present study is to examine the trends in inequalities in height in France as a function of education and income using 4 waves of data that cover birth years from 1906 to 1978. We use a weighted summary index, the slope index of inequality to be described below,(Mackenbach & Kunst, 1997) to allow comparisons to be made across time despite changes in the population distribution of education and income.

Numerous studies have shown that socioeconomic position across the lifecourse is associated with health and well-being (Hallqvist *et al.*, 2004; Lynch & Smith, 2005). The two socioeconomic indicators used in this study, education and income, come from different points in the lifecourse. Education reflects early socioeconomic circumstances, including parental social position. Income is a later life measure of socioeconomic circumstances, which can change over the adult life course and is therefore less tightly connected with socioeconomic origins. Furthermore, education is mostly unchanging once one enters professional life whereas income continues to change over adulthood. Estimation of height inequalities related to both education and income, particularly that for income after adjustment for education, will allow us to shed light on the “discrimination” hypothesis (Magnusson *et al.*, 2006).

2.1 Data

Data are drawn from the Decennial Health Surveys (DHS, Enquête Décennale Santé, http://www.irdes.fr/EspaceRecherche/Enquetes/EnqueteSanteSoinsMed.htm) of 1970, 1980, 1991 and 2003. The DHS data are collected every 10 years by the French National Institute of Statistics and Economic Studies (Institut National de la Statistique et des Etudes Economiques, INSEE) using a multistage, stratified, random survey of households sampled on the basis of data from the last available national population census. A random sample of households, at least 5% in each strata, is drawn from the census list of households stratified on regions in France and using 5 categories of population density (rural, <20 000 inhabitants, between 20 000 and 100 000 habitants, ≥100 000 inhabitants, and Paris). The DHS surveys are representative of the French population with the exception of people in institutions (e.g., retirement homes, religious communities, prisons and hospitals), mobile homes and the homeless; approximately 98% coverage of the entire population (Maillard *et al.*, 1999). Using a combination of face-to-face interviews and self-administered questionnaires, the DHS collects data at the individual and household levels, including information on demographic characteristics, socioeconomic and health status, insurance coverage complementary to the basic coverage provided to all French residents and the use of medical care. The response rate in the four surveys was as follows 64.2% (1970), 63.7% (1980), 66.3% (1991), and 68.4% (2003).

2.2 Variables

Education, based on participants' report, was assessed as the highest achieved education level, categorised into six levels: no formal education, primary school, lower secondary school, vocational qualification, "Baccalauréat" (secondary school diploma, usually taken at age 18), and higher than "Baccalauréat".

Income measure was annual household income reported by the participant (de Saint, 2009). In the event the respondent did not want to provide precise information on income, they were offered a range, and the mid value of this range was considered to be the household income. The French National Institute for Statistics and Economic Studies (INSEE), which carried out the surveys, has a complex procedure of imputation of income for those with missing values. The measure of income used in the analysis was further converted to income per consumption unit to reflect household size and composition. In France, INSEE defines consumption units as follows: the first adult (head) of a multiple-person household as 1 unit, subsequent adults and children over 14 in the household as 0.5 units and children under 14 as 0.3 unit.

Height was self-reported in all four surveys.

Place of birth was a multiple choice question on nationality with the following response categories: born in France, acquired French nationality, or of another nationality. This measure was included only in the 1991 and 2003 survey and we will analyse these two years separately in order to ascertain the extent to which birthplace affects our results.

3. Methods

The association between height and the two measures of SEP, first education and then income, was examined using the slope index of inequality (SII) (Mackenbach & Kunst, 1997). The socioeconomic groups were first ordered from highest to lowest. The population of each socioeconomic group, each category in the case of education and each value in the case of household income, was assigned a ridit score (a fractional rank from 0 for the highest SEP to 1 for the lowest SEP), based on the midpoint of their range in the cumulative distribution in the population. For example, if the highest category for education comprises 20% of the population, each individual in this category is assigned a value of 0.1 (0.2/2), and if the second highest category comprises 30% of the population, the corresponding individuals are assigned a value of 0.35 (0.2 + (0.3/2)), and so forth. Height was then regressed on the ridit score, the beta or slope coefficient is the SII and represents the predicted difference in height between the theoretical highest (percentile rank 0) and lowest (percentile rank 100) educational level in the population. The SII has considerable advantage for comparisons across time as it takes into account the changing size of the education categories or income. An additional advantage is that the fractional rank allows the size of the socioeconomic groups to be taken into consideration. The resulting estimate of inequality thus uses all the available data and is not restricted to comparisons between extreme socioeconomic groups.

We calculated the SII using the DHS data from 1970, 1980, 1991 and 2003 for education and income. We categorised individuals into four groups: 25–34 years, 35–44 years, 45–54 years and 55–64 years for age-group specific analyses. For each survey year and for the four age-groups, we calculated the fractional ranks for education and income. We also examined overall trends in men and women aged 25–64 years; these latter analyses were adjusted for age, treated as a continuous variable. A linear test for trend was used to examine whether inequalities increased over time. The analysis using income also involved adjustment for education as a second step. Sampling weights provided by INSEE were used to correct for systematic non-response bias. This procedure allows data to be weighted in an inversely proportional relationship to the non-response probabilities of individuals with the goal of the data being representative of the French population.

French constitutional law embraces equality as a founding principle and prohibits the collection of data on race, ethnicity or religion. As it is well known that race and ethnicity are associated with body size (Bogin & Rios, 2003), we undertook further analyses in order to assess the extent to which our results were influenced by immigration into France. For the last two waves, 1991 and 2003, the DHS surveys included information of whether the participant “was born in France”. 92.2% of the men and 92.9% of the women surveyed in 1991 indicated that they had been born in France; the corresponding figure in 2003 was 89.8% for both sexes. We reanalysed inequalities related to education and income in this subgroup for the surveys conducted in 1991 and 2003. It must be noted that this is only an indirect measure of “ethnicity” and does not allow us to exclude non-Caucasians if they were born in France

All analyses were performed using the statistical software Stata, version 10.

4. Results

Table 1 presents the average height of men and women in four age-groups and for the four DHS surveys. For any given survey year, height decreased with age. This increasing trend in mean height in recent years was also suggested by the increase in height in all age-groups in the later surveys compared to the earlier surveys. Table 1 also shows the proportion of the population educated at least to “Baccalauréat” level to increase.

Table 2 shows the height advantage of the most educated group (qualification higher than “Baccalauréat”, secondary school diploma, usually taken at age 18) compared to the least educated those with “no formal education”. Interpretation of the differences is made difficult by the fact that the composition of these groups changed over the survey years. In men, the least educated group shrank over the survey years from 34.2% in 1970, to 27% 1980 and then to 19.7% and 14.7% in the 1991 and 2003 surveys, respectively. The size of the most educated group grew from 4.6% in 1970 to 27% in 2003. In women the changes were similar. The least educated groups over the four surveys were: 37.6% (1970), 28.6% (1980), 21.2% (1991) and

15.6% (2003). The most educated group grew from 2.5% in 1970 to 27.7% in 2003. Thus, it is difficult to interpret these results in any meaningful way.

Next we estimate the linear gradient of the relationship between education and height using the index of inequality, rather than the discrete education categories as in Table 2. In Table 3 we present the mean difference between the most and least educated individuals using the estimated slope parameter. The test for trend suggests no evidence of increasing or decreasing inequality in height in men, except for the oldest age group where there appears to be some evidence of increasing inequality. The results for women also tend to show persistent educational inequalities in height over time. The analysis of men and women of all age-groups combined together show greater inequalities in men than in women at all survey phases.

Table 4 shows results using income to assess inequalities in height in the four survey years using the SII slope estimates. Here again, the height inequalities were greater in men than in women. These inequalities, albeit smaller than those associated with education, also appear to have remained unchanged over time in men with some evidence of an increase in women. Next, these analyses were adjusted for the effect of education by entering it into the regression containing the ridit score for income as the predictor variable (Table 5). There are two key findings. First, inequalities in height related to income were much attenuated after adjustment for education. Second, inequalities in men remained larger than in women and there was no trend among men but some evidence of a trend among women

Table 6 shows height differences of those born in France as a function of education and income and are comparable to the results on the total population presented in tables 2 and 3. Analysis restricted to those born in France somewhat reduces the inequalities but they still remain substantial. There were no differences in inequalities at the surveys 1991 and 2003. Income related inequalities in this sub-group when adjusted for education yielded results similar to that using all the data (results not shown).

5. Discussion

The four Decennial Health Surveys cover three decades and birth cohorts from approximately 1906 to 1978. Analysis using these data reveals that height in France has continued to increase over this period. However, education-related inequalities in height, at between 4.5–5.6 cm in men and 2.4–3.1 cm in women depending on the survey year, have remained basically unchanged over this period. The association between income and height is smaller and confounded by the effect of education. The principal strength of the study is the wide observation window used to examine social inequalities in height in a dataset which represents the French population at each of the four time points. A further strength is the use of estimates of absolute inequality in height that are comparable across time.

5.1 Comparison with other studies

Previous analysis of historical data from the time of the French revolution shows that men from an elite academic institution, the Ecole Polytechnique, were 7 cm taller than their countrymen (Komlos *et al.*, 2003). We found a mean 5 cm increase in height between 1970 and 2003 in men and a 2 cm increase in women, with no real change in gender differences in height. Recent analysis of Swedish data from the 10^{th} to the end of the 20^{th} century shows no real increase in gender differences in height (Gustafsson *et al.*, 2007). It has been suggested that both genetic and environmental factors, diet in particular, may lie behind gender differences in height (Costa-Font & Gil, 2008; Gray & Wolfe, 1980).

The fact that height increased over the observational period in our study is in keeping with other historical data on secular increases in height in European countries starting from as far back as the middle of the 19th century (Floud, 1989; Gustafsson *et al.*, 2007). Height of the French male population, drawn from military records, born between 1660 and 1760 has been shown to vary as a function of the socioeconomic environment (Komlos *et al.*, 2003). Such trends cannot be explained by genetic influences. Indeed, despite the large heritability component of body height, the importance of environmental factors is seen to be non negligible as they contribute to 20% of the within population variation in height (McEvoy & Visscher, 2009; Silventoinen *et al.*, 2003). Striking examples of the importance of environmental factors also come from evidence on growth plasticity in immigrant children (Bogin & Loucky, 1997; Smith *et al.*, 2003). Maya children living in the United States were reported to be 11.54 cm taller than those living in Guatemala (Bogin *et al.*, 2002).

One key issue in examining trends in the association between height and socioeconomic indicators is to assess whether secular increases in height, improving socioeconomic conditions and establishment of the welfare state has eradicated this association in recent cohorts. Our results show this not to be the case in France, a wealthy Western European country with universal health care since 1945. We use data that are representative of the French population; however, we did not examine whether the trend in the association between socioeconomic factors and height was similar in all regions of France. Our data on place of residence are accurate but as these are cross-sectional surveys we do not have information of the place of residence over the lifecourse and we can take geographical mobility within France into account in the analysis. Thus, we chose to focus on trends over time in France, using data that are representative of France.

In principle, the association between markers of socioeconomic circumstances and height could be due either to; a common cause, due to the consequence of poor nutrition and diseases in childhood, or due to processes such as discrimination in the labour market. The first explanation views common social, psychological or biological factors as being responsible for both height and education. Data from the Stockholm Birth Cohort Study show the net effect of height on education, given a certain level of cognition, to be modest (Vagero & Modin, 2006). Many authors emphasize the second explanation, childhood nutrition or disease, for social inequalities in adult stature (Cavelaars *et al.*, 2000; Peck & Vagero, 1987; Silventoinen *et al.*, 2001). A recent paper supports the third explanation, discrimination against short stature in the labour market, as it found childhood SEP and cognitive ability to explain little of the education-height association (Magnusson *et al.*, 2006). Further support for the discrimination hypothesis comes from French data showing that even after controlling for educational achievement taller men have better careers as they are given more supervisory responsibilities (Herpin, 2005).

Our analysis provides indirect evidence against discrimination in the labour market as an explanation for inequalities. We found greater inequalities with education rather than income and furthermore income inequalities were substantially attenuated after adjustment for education. Education, often used as a proxy indicator of childhood SEP, is associated with later life measures such as occupational position and income(Singh-Manoux *et al.*, 2002) and is likely to be a confounder of the association between income and height. Substantial attenuation of this association after adjustment for education suggests that discrimination against short stature is not a major explanation of social inequalities in height. Similarly, other studies have shown a weaker association between height and adult SEP than childhood SEP (Power *et al.*, 2002; Silventoinen *et al.*, 2001).

In general, socioeconomic factors in childhood might influence height through their effect on living conditions such as bad housing, malnutrition or inadequate access to health care. However, economic development and health care provision in France suggests that these are unlikely to be important in more recent birth cohorts. Cavelaars et al suggest that improvements in the living conditions of the lower socioeconomic groups might have been counterbalanced by other adverse factors such as unbalanced diets and maternal smoking (Cavelaars *et al.*, 2000). This is a plausible hypothesis and along with alcohol consumption in pregnancy needs further exploration in future studies.

5.2 Trends in social inequalities: Methodological issues

There are several methodological issues that beset analysis of trends in the association between SEP and height. First, age related shrinkage in height requires the analysis to be able to separate ageing effects from those of birth cohort effects (Cline *et al.*, 1989). We grouped age into 10 year bands to examine height differences as a function of SEP in each age-group. Thus, the effect of shrinkage is unlikely to play a major role in the conclusions drawn in our study.

Second, the choice of method used to assess social inequalities and trends in inequalities is not straight forward and increasingly seen to be an important issue (Keppel *et al.*, 2005; Krieger *et al.*, 2008). Inequalities in an outcome measure such as height can be analysed in two ways. The first involves a pair-wise comparison either with each socioeconomic group compared to a reference group or height difference between extreme categories of a measure of SEP. The second involves use of a summary measure, as is the case in our analysis, where the interest is in the inequality in height across the entire distribution of the socioeconomic measure. Summary measure of social inequality can either be unweighted or weighted to reflect the population distribution of the socioeconomic indicator under consideration.

Much research on social inequalities in height uses unweighted pair wise comparisons. For example, the results from 10 European countries showing height difference of 1.6 – 3.0 cm in men and 1.2 – 2.2 cm in women between the low and high education groups do not take the size of these groups into account (Cavelaars *et al.*, 2000). Cavelaars and colleagues categorised the 5-level measure of education from the 10 countries into two groups, low and high education as those with less and more than upper secondary school education. These provide relatively robust results even though there is tremendous loss of information on the measure of education. Furthermore, had the comparisons been based on the 5 level measure, it is possible that the extreme education categories, here no education and a university degree or more, would have had a different population distribution in the 10 European countries. Use of a summary weighted index in this scenario would have allowed estimations of inequality in height across the population distribution of education.

Use of weighted summary indices is particularly valuable for the analysis of trends in social inequalities in height. For instance, a British study reported that the average height of manual workers born in 1938 was the same as that of non-manual workers born in 1920 without taking into account changes in the proportion of the population engaged in manual work (Walker *et al.*, 1988). Unweighted measures of trends in social inequalities imply that the interest is in a specific socioeconomic group, regardless of its share of the population over time. Thus, had our research objective been to examine the height disadvantage among those with “no education” across the 4 surveys from 1970, 1980, 1991, and 2003 we would not have used summary indices. However, our objective was to examine trends in social inequalities in height across the 4 surveys and not using weighted indices would bias the results. For example, a 25 year old man with no education in 1970 survey is likely have different characteristics from someone the same age with no education in 2003 in his social and behavioural profile and indeed in his employment prospects. Table 1 clearly shows the improving education levels over time, or the cohort effects, in these data. Comparing extreme educational groups over time is meaningless as a 25 year old man with no education in 2003 is in the minority.

The advantage of using SII is that it is a weighted index with the weights being the proportions of the population in each education category or income measure. The SII incorporates the average height in all groups and the proportions of the population they reflect. Education measures are prone to cohort effects due to upward secular trends in educational attainment among all groups (Hadden, 1996). Our use of a weighted summary index allows us to incorporate the changing structure of educational achievement within a society. Thus, the SII is interpreted as the average difference in height over the entire population ordered by level of the socioeconomic indicator. An SII of 0 would indicate that there is no consistent relationship between height and the socioeconomic variable. There is considerable evidence to show that the association between measures of socioeconomic position and height is linear (Magnusson *et al.*, 2006; Whincup *et al.*, 1988), allowing easy interpretation of this index.

The SII does not show social inequalities in height to have decreased over the four survey years in France; in women there is some evidence of an increase. It is possible that the increase in inequalities in women is related to the changing economic role of women in that as they enter the labour market in larger numbers, they are more subject to discrimination. It must be noted that the income related inequalities in women are no larger than those related to education so discrimination in the labour market is not a complete explanation of increasing inequalities in women. It must also be noted that the increase in inequalities in women is not consistent in our data as it is not evident in every age-group.

Previous research on adult height, despite methodological limitations, mostly suggests persistence in social inequalities (Cavelaars *et al.*, 2000; Kuh *et al.*, 1991; Silventoinen *et al.*, 2001; Walker *et al.*, 1988). However, some studies suggest a trend of decreasing inequalities (Peck & Vagero, 1987), with greater secular increases in height in the lower socioeconomic groups seen to be the explanation of this reduction in social inequalities in height (Peck & Vagero, 1987). This hypothesis makes sense as the last century has seen the emergence of welfare states and universal health care in most European countries. Nevertheless, our data, using a wider observation window than has been possible previously, suggest no reduction in social inequalities in height.

Finally, recent immigration could be an artefactual explanation of the persistence of height inequalities in France. However, immigrants compose under 10% of the French population, a figure that has been stable for the last 25 years (Boeldieu & Borrel, 2000). Furthermore, we were able to repeat the analysis for the last two surveys on participants born in France and these estimates do not provide evidence for immigration as an explanation of the results. Nevertheless, these results need to be interpreted with the “healthy immigrant effect” in mind as filtering through self-selection, official health screening, and employability, are seen to select healthier immigrants relative to those left behind.

The use of self-reported rather than directly measured height is a limitation in our study. It is well known that height is overestimated in self-report data, particularly among men (Niedhammer *et al.*, 2000) and this has also been shown with the DHS data (Dauphinot *et al.*, 2009). There is some evidence to suggest an underestimation of socioeconomic differences in height when it is self-reported (Bostrom & Diderichsen, 1997; Niedhammer *et al.*, 2000). Therefore, the use of self-reported data is problematic when the goal is to assess social inequalities as socioeconomic indicators might influence the reporting of height, leading to an under or an over estimation of social inequalities. However, when the goal is the assessment of trends over time, as in our case, then the results are biased if socioeconomic factors influence reporting of height differently at different time periods. This is unlikely and there is no reason for the analysis of trends to be biased when height is self-reported at every survey (Bostrom & Diderichsen, 1997). In surveys, the precise method used to collect self-reported data has been shown to influence discrepancies between measured height and self-reported height with in-person interviews, like in the DHS, showing less bias than telephone interviews (Ezzati *et al.*, 2006). For our analysis, the key point is not the extent of the bias in self-reported height but whether the bias changes over time. Ezzati and colleagues use data from the American National Health and Nutrition Examination Surveys (NHANES) to show that the difference between self-reported and measured anthropometric data run parallel over time. Thus, one can conclude that the analysis on trends in height over time, are unlikely to be biased in our study. A final caveat is related to change in data collection methods in the DHS surveys. Until 1991 one person in the household provided information on all members of the household, but at the 2003 survey a decision was made to collect data on individual characteristics such as height from the individuals themselves (Caron & Rousseau, 2005). In these data, no change in social inequalities in height was seen after this change in methodology, suggesting that methodological bias in trends is unlikely. Indeed previous analysis of trends in obesity shows self-report data accurately to reflect the trend in France (de Saint, 2009; Singh-Manoux *et al.*, 2009).

In summary, our analysis based on cross-sectional surveys repeated four times suggests no decrease in absolute social inequalities in height in France between birth cohorts from 1906 to 1978, either as a function of education or of income.

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Reference List

Batty GD, Shipley MJ, Gunnell D, Huxley R, Kivimaki M, Woodward M, Lee CM, Smith GD. Height, wealth, and health: an overview with new data from three longitudinal studies. Economics and Human Biology 2009;7:137–152. [PubMed: 19628438]

Billewicz WZ, Thomson AM, Fellowes HM. A longitudinal study of growth in Newcastle upon Tyne adolescents. Annals of Human Biology 1983;10:125–133. [PubMed: 6838161]

Boeldieu J, Borrel C. Recensement de la population 1999. La proportion d’immigrés est stable depuis 25 ans. 2000

Bogin B, Loucky J. Plasticity, political economy, and physical growth status of Guatemala Maya children living in the United States. American Journal of Physical Anthropology 1997;102:17–32. [PubMed: 9034036]

Bogin B, MacVean RB. The relationship of socioeconomic status and sex to body size, skeletal maturation, and cognitive status of Guatemala City schoolchildren. Child Development 1983;54:115–128. [PubMed: 6831980]

Bogin B, Rios L. Rapid morphological change in living humans: implications for modern human origins. Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology 2003;136:71–84.

Bogin B, Smith P, Orden AB, Varela Silva MI, Loucky J. Rapid change in height and body proportions of Maya American children. American Journal of Human Biology 2002;14:753–761. [PubMed: 12400036]

Bostrom G, Diderichsen F. Socioeconomic differentials in misclassification of height, weight and body mass index based on questionnaire data. International Journal of Epidemiology 1997;26:860–866. [PubMed: 9279620]

Caron, N.; Rousseau, S. INSEE. Correction de la non-réponse et calage de l’enquête santé 2002. 2005.

Cavelaars AE, Kunst AE, Geurts JJ, Crialesi R, Grotvedt L, Helmert U, Lahelma E, Lundberg O, Mielck A, Rasmussen NK, Regidor E, Spuhler T, Mackenbach JP. Persistent variations in average height between countries and between socio-economic groups: an overview of 10 European countries. Annals of Human Biology 2000;27:407–421. [PubMed: 10942348]

Cline MG, Meredith KE, Boyer JT, Burrows B. Decline of height with age in adults in a general population sample: estimating maximum height and distinguishing birth cohort effects from actual loss of stature with aging. Human Biology 1989;61:415–425.

Cole TJ. Secular trends in growth. Proceedings of the Nutrition Society 2000;59:317–324. [PubMed: 10946801]

Cole TJ. The secular trend in human physical growth: a biological view. Economics and Human Biology 2003;1:161–168. [PubMed: 15463971]

Costa-Font J, Gil J. Generational effects and gender height dimorphism in contemporary Spain. Economics and Human Biology 2008;6:1–18. [PubMed: 18060848]

Dauphinot V, Wolff H, Naudin F, Gueguen R, Sermet C, Gaspoz JM, Kossovsky MP. New obesity body mass index threshold for self-reported data. Journal of Epidemiology and Community Health 2009;63:128–132. [PubMed: 18801799]

de Saint Pol T. Evolution of obesity by social status in France, 1981–2003. Economics and Human Biology 2009;7:398–404. [PubMed: 19617008]

Deaton A, Arora R. Life at the top: the benefits of height. Economics and Human Biology 2009;7:133–136. [PubMed: 19596614]

Ezzati M, Martin H, Skjold S, Vander HS, Murray CJ. Trends in national and state-level obesity in the USA after correction for self-report bias: analysis of health surveys. Journal of the Royal Society of Medicine 2006;99:250–257. [PubMed: 16672759]

Floud, R. Measuring European Inequality, the use of height data. In: Fox, AJ., editor. Health Inequalities in Eurpean Countries. Aldershot; Gower: 1989.

Gray JP, Wolfe LD. Height and sexual dimorphism of stature among human societies. American Journal of Physical Anthropology 1980;53:441–456. [PubMed: 7468783]

Gustafsson A, Werdelin L, Tullberg BS, Lindenfors P. Stature and sexual stature dimorphism in Sweden, from the 10th to the end of the 20th century. American Journal of Human Biology 2007;19:861–870. [PubMed: 17712787]

Hadden WC. Annotation: the use of educational attainment as an indicator of socioeconomic position. American Journal of Public Health 1996;86:1525–1526. [PubMed: 8916514]

Hallqvist J, Lynch J, Bartley M, Lang T, Blane D. Can we disentangle life course processes of accumulation, critical period and social mobility? An analysis of disadvantaged socio-economic positions and myocardial infarction in the Stockholm Heart Epidemiology Program. Social Science and Medicine 2004;58:1555–1568. [PubMed: 14759698]

Herpin N. Love, careers, and heights in France, 2001. Economics and Human Biology 2005;3:420–449. [PubMed: 15894522]

Keppel K, Pamuk E, Lynch J, Carter-Pokras O, Kim I, Mays V, Pearcy J, Schoenbach V, Weissman JS. Methodological issues in measuring health disparities. Vital Health Stat 2005;2:1–16.

Komlos J, Hau M, Bourginat N. An Anthropometric History of Early-Modern France. European Review of Economic History 2003;7:159–189.

Komlos J, Kriwy P. Social status and adult heights in the two Germanies. Annals of Human Biology 2002;29:641–648. [PubMed: 12573080]

Krieger N, Rehkopf DH, Chen JT, Waterman PD, Marcelli E, Kennedy M. The fall and rise of US inequities in premature mortality: 1960–2002. PLoS Med 2008;5:e46. [PubMed: 18303941]

Kuh DL, Power C, Rodgers B. Secular trends in social class and sex differences in adult height. International Journal of Epidemiology 1991;20:1001–1009. [PubMed: 1800396]

Li L, Power C. Influences on childhood height: comparing two generations in the 1958 British birth cohort. International Journal of Epidemiology 2004;33:1320–1328. [PubMed: 15358746]

Liestol K, Rosenberg M. Height, weight and menarcheal age of schoolgirls in Oslo--an update. Annals of Human Biology 1995;22:199–205. [PubMed: 7574445]

Lynch J, Smith GD. A life course approach to chronic disease epidemiology. Annuual Review of Public Health 2005;26:1–35.

Mackenbach JP, Kunst AE. Measuring the magnitude of socio-economic inequalities in health: an overview of available measures illustrated with two examples from Europe. Social Science and Medicine 1997;44:757–771. [PubMed: 9080560]

Magnusson PK, Rasmussen F, Gyllensten UB. Height at age 18 years is a strong predictor of attained education later in life: cohort study of over 950,000 Swedish men. International Journal of Epidemiology 2006;35:658–663. [PubMed: 16446353]

Maillard G, Charles MA, Thibult N, Forhan A, Sermet C, Basdevant A, Eschwege E. Trends in the prevalence of obesity in the French adult population between 1980 and 1991. International journal of obesity and related metabolic disorders 1999;23:389–394. [PubMed: 10340817]

Marmot MG, Shipley MJ, Rose G. Inequalities in death--specific explanations of a general pattern? Lancet 1984;1:1003–1006. [PubMed: 6143919]

McEvoy BP, Visscher PM. Genetics of human height. Economics and Human Biology 2009;7:294–306. [PubMed: 19818695]

Meyer HE, Selmer R. Income, educational level and body height. Annals of Human Biology 1999;26:219–227. [PubMed: 10355493]

Moradi A. Nutritional Status and Economic Development in Sub-Saharan Africa, 1950–1980. Economics and Human Biology. 2010

Niedhammer I, Bugel I, Bonenfant S, Goldberg M, Leclerc A. Validity of self-reported weight and height in the French GAZEL cohort. International journal of obesity and related metabolic disorders 2000;24:1111–1118. [PubMed: 11033979]

Peck AM, Vagero DH. Adult body height and childhood socioeconomic group in the Swedish population. Journal of Epidemiology and Community Health 1987;41:333–337. [PubMed: 3502672]

Power C, Manor O, Li L. Are inequalities in height underestimated by adult social position? Effects of changing social structure and height selection in a cohort study. BMJ 2002;325:131–134. [PubMed: 12130607]

Rona RJ, Swan AV, Altman DG. Social factors and height of primary schoolchildren in England and Scotland. Journal of Epidemiology and Community Health 1978;32:147–154. [PubMed: 711973]

Silventoinen K. Determinants of variation in adult body height. Journal of Biosocial Science 2003;35:263–285. [PubMed: 12664962]

Silventoinen K, Lahelma E, Lundberg O, Rahkonen O. Body height, birth cohort and social background in Finland and Sweden. European Journal of Public Health 2001;11:124–129. [PubMed: 11420796]

Silventoinen K, Sammalisto S, Perola M, Boomsma DI, Cornes BK, Davis C, Dunkel L, De Lange M, Harris JR, Hjelmborg JV, Luciano M, Martin NG, Mortensen J, Nistico L, Pedersen NL, Skytthe A, Spector TD, Stazi MA, Willemsen G, Kaprio J. Heritability of adult body height: a comparative study of twin cohorts in eight countries. Twin Research 2003;6:399–408. [PubMed: 14624724]

Singh-Manoux A, Clarke P, Marmot M. Multiple measures of socio-economic position and psychosocial health: proximal and distal measures. International Journal of Epidemiology 2002;31:1192–1199. [PubMed: 12540721]

Singh-Manoux A, Gourmelen J, Lajnef M, Sabia S, Sitta R, Menvielle G, Melchior M, Nabi H, Lanoe JL, Gueguen A, Lert F. Prevalence of educational inequalities in obesity between 1970 and 2003 in France. Obesity Reviews 2009;10:511–518. [PubMed: 19460112]

Smith PK, Bogin B, Varela-Silva MI, Loucky J. Economic and anthropological assessments of the health of children in Maya immigrant families in the US. Economics and Human Biology 2003;1:145–160. [PubMed: 15463970]

Vagero D, Modin B. Commentary: the associations between height, cognition, and education and their relevance for health studies. International Journal of Epidemiology 2006;35:663–664. [PubMed: 16690757]

Walker M, Shaper AG, Wannamethee G. Height and social class in middle-aged British men. Journal of Epidemiology and Community Health 1988;42:299–303. [PubMed: 3251013]

Whincup PH, Cook DG, Shaper AG. Social class and height. British Medical Journal 1988;297:980–981. [PubMed: 3142581]

Table 1

Data on height and education from 4 Decennial Health Surveys (DHS) 1970–2003 for samples of adult * men and women representative of the French population.

	DHS 1970			DHS 1980			DHS 1991			DHS 2003		
Age	**N**	**HEIGHT† M (SD)**	**≥ BAC %‡**	**N**	**HEIGHT† M (SD)**	**≥ BAC %‡**	**N**	**HEIGHT† M (SD)**	**≥ BAC %‡**	**N**	**HEIGHT† M (SD)**	**≥ BAC %‡**
Men												
25–34	1220	171.9 (6.4)	24	1512	173.7 (6.6)	29	1436	175.6 (7.0)	31	2060	177.0 (6.8)	56
35–44	1576	170.4 (6.5)	16	1161	172.1 (6.6)	22	1526	174.2 (6.6)	31	2493	176.0 (6.8)	38
45–54	1225	169.9 (6.4)	15	1298	170.8 (6.4)	17	1097	172.5 (6.8)	28	2448	174.4 (6.6)	35
55–64	1133	169.0 (6.0)	11	963	169.9 (6.4)	14	1034	170.9 (6.6)	16	1708	173.0 (6.6)	32
ALL	5154	170.3 (6.4)	17	4934	171.8 (6.6)	21	5093	173.5 (7.0)	27	8709	175.2 (6.9)	40
Women												
25–34	1304	161.2 (5.9)	18	1534	161.5 (5.9)	30	1623	163.0 (6.0)	35	2288	164.0 (6.1)	62
35–44	1610	160.5 (6.0)	12	1193	161.2 (6.1)	22	1563	161.9 (6.3)	31	2778	163.2 (6.1)	45
45–54	1300	160.9 (5.8)	12	1357	160.5 (5.9)	13	1131	161.4 (5.9)	23	2668	161.8 (6.4)	35
55–64	1191	160.2 (5.9)	67	1012	160.5 (6.1)	11	1140	160.4 (5.9)	9	1926	161.2 (6.0)	26
ALL	5405	160.7 (5.9)	12	5096	161.0 (6.0)	20	5457	161.8 (6.1)	26	9660	162.6 (6.3)	43

* Analysis restricted to those 25 to 64 years of age.

† M: Mean; SD: Standard deviation.

‡ Those with a baccalauréat (secondary school diploma, usually taken at age 18), or higher.

Table 2

Difference in height between the most and the least educated using conventional categories of education.†

Age	1970 beta (95% CI)	1980 beta (95% CI)	1991 beta (95% CI)	2003 beta (95% CI)	p for trend
Men					
25–34	4.15 (2.60, 5.70)	4.30 (3.16, 5.45)	4.52 (3.28, 5.77)	2.81 (1.64, 3.97)	0.22
35–44	5.79 (3.99, 7.60)	4.20 (2.96, 5.44)	5.04 (3.91, 6.17)	3.83 (2.92, 4.75)	0.12
45–54	4.21 (2.36, 6.07)	4.68 (3.48, 5.89)	5.78 (4.39, 7.17)	4.25 (3.34, 5.17)	0.71
55–64	4.52 (2.82, 6.21)	4.61 (3.25, 5.97)	4.50 (2.95, 6.05)	4.88 (3.81, 5.95)	0.76
Women					
25–34	3.14 (1.77, 4.52)	2.35 (1.30, 3.41)	2.17 (1.16, 3.18)	1.47 (0.53, 2.42)	0.05
35–44	1.78 (−0.61, 4.17)	2.52 (1.37, 3.68)	2.68 (1.58, 3.78)	2.41 (1.64, 3.19)	0.60
45–54	3.81 (2.25, 5.36)	2.25 (0.91, 3.58)	3.89 (2.78, 5.00)	2.45 (1.57, 3.33)	0.40
55–64	1.66 (−0.20, 3.53)	1.24 (−0.69, 3.18)	2.35 (0.63, 4.06)	3.32 (2.34, 4.31)	0.08
All Ages **25–64**‡					
men	4.77 (3.90, 5.65)	4.39 (3.77, 5.01)	4.92 (4.26, 5.58)	3.84 (3.33, 4.35)	0.16
women	2.79 (1.86, 3.72)	2.22 (1.58, 2.86)	2.68 (2.10, 3.26)	2.26 (1.81, 2.71)	0.49
p- value for GENDER DIFFERENCES all ages 25–64‡					
	p < 0.001	p < 0.001	p < 0.001	p < 0.001	

†Estimates drawn from regression, comparing those with “no formal education” to those with a “higher than “Baccalauréat” (secondary school diploma, usually taken at age 18) qualification.

‡Adjusted for age as a continuous variable.

Table 3

The education gradient in height using the Slope Index of Inequality.[†]

	1970	1980	1991	2003	
Age	**SII (95% CI)** [§]	**SII (95% CI)** [§]	**SII (95% CI)** [§]	**SII (95% CI)** [§]	**p for trend**
			Men		
25–34	4.27 (2.95, 5.60)	4.44 (3.26, 5.63)	4.91 (3.55, 6.27)	3.96 (2.80, 5.12)	0.87
35–44	5.40 (4.23, 6.56)	4.57 (3.20, 5.93)	5.64 (4.45, 6.83)	4.56 (3.54, 5.58)	0.57
45–54	4.47 (3.16, 5.79)	4.88 (3.63, 6.13)	6.44 (4.98, 7.90)	4.92 (3.92, 5.92)	0.29
55–64	3.24 (1.87, 4.60)	4.41 (2.97, 5.86)	5.22 (3.75, 6.68)	5.78 (4.59, 6.97)	0.004
			Women		
25–34	2.34 (1.16, 3.52)	3.19 (2.12, 4.26)	2.52 (1.43, 3.62)	2.38 (1.37, 3.38)	0.82
35–44	2.79 (1.65, 3.92)	2.61 (1.36, 3.85)	3.35 (2.22, 4.49)	3.02 (2.14, 3.91)	0.54
45–54	2.18 (0.98, 3.37)	1.58 (0.39, 2.78)	4.39 (3.20, 5.59)	3.38 (2.45, 4.31)	0.009
55–64	2.15 (0.87, 3.43)	1.29 (−0.25, 2.82)	2.17 (0.88, 3.46)	3.25 (2.20, 4.30)	0.13
			All Ages **25–64**[‡]		
men	4.48 (3.82, 5.14)	4.71 (4.03, 5.38)	5.58 (4.88, 6.27)	4.69 (4.14, 5.25)	0.29
women	2.41 (1.80, 3.02)	2.37 (1.73, 3.02)	3.14 (2.53, 3.76)	2.96 (2.46, 3.47)	0.06
			p- value for GENDER DIFFERENCES all ages 25–64[‡]		
	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	

[†]All analyses weighted to be representative of the French population.

[§]SII: Slope Index of Inequality; CI: Confidence Interval

[‡]Adjusted for age as a continuous variable.

Table 4

The income gradient in height using the Slope Index of Inequality.[†]

Age	1970 SII (95% CI) [§]	1980 SII (95% CI) [§]	1991 SII (95% CI) [§]	2003 SII (95% CI) [§]	p for trend
Men					
25–34	2.83 (1.58, 4.09)	4.12 (2.93, 5.32)	4.82 (3.44, 6.20)	2.71 (1.62, 3.80)	0.91
35–44	3.66 (2.55, 4.77)	3.39 (2.01, 4.78)	4.15 (2.96, 5.34)	3.52 (2.50, 4.54)	0.89
45–54	3.62 (2.23, 5.00)	3.22 (1.95, 4.49)	3.95 (2.53, 5.36)	3.71 (2.71, 4.71)	0.72
55–64	2.79 (1.48, 4.09)	3.91 (2.49, 5.33)	4.56 (3.13, 6.00)	3.99 (2.79, 5.19)	0.14
Women					
25–34	1.89 (0.70, 3.09)	2.27 (1.23, 3.31)	3.08 (1.99, 4.17)	2.03 (1.07, 2.99)	0.62
35–44	1.40 (0.30, 2.51)	1.26 (0.07, 2.44)	2.89 (1.77, 4.02)	2.80 (1.93, 3.67)	0.01
45–54	1.62 (0.48, 2.77)	0.17 (−0.99, 1.33)	1.29 (−0.01, 2.59)	2.12 (1.22, 3.03)	0.28
55–64	1.59 (0.33, 2.84)	0.43 (−0.97, 1.83)	1.45 (0.13, 2.77)	2.85 (1.82, 3.87)	0.07
All Ages **25–64**[‡]					
men	3.26 (2.63, 3.89)	3.66 (3.00, 4.32)	4.32 (3.64, 5.00)	3.44 (2.90, 3.97)	0.38
women	1.67 (1.08, 2.26)	1.10 (0.51, 1.69)	2.27 (1.67, 2.87)	2.43 (1.96, 2.90)	0.005
p- value for GENDER DIFFERENCES all ages 25–64[‡]					
	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.005$	

[†] All analyses weighted to be representative of the French population.

[§] SII: Slope Index of Inequality; CI: Confidence Interval

[‡] Adjusted for age as a continuous variable.

Table 5

The income gradient in height, adjusted for education, using the Slope Index of Inequality.[†]

	1970	1980	1991	2003	
Age	**SII (95% CI) [§]**	**SII (95% CI) [§]**	**SII (95% CI) [§]**	**SII (95% CI) [§]**	**p for trend**
			Men		
25–34	1.38 (0.02, 2.75)	2.74 (1.48, 4.00)	3.71 (2.22, 5.21)	1.28 (0.04, 2.51)	0.83
35–44	1.80 (0.55, 3.05)	1.64 (0.14, 3.14)	2.08 (0.69, 3.48)	2.03 (0.91, 3.15)	0.68
45–54	2.07 (0.58, 3.57)	1.54 (0.17, 2.92)	1.31 (−0.25, 2.86)	2.00 (0.87, 3.13)	0.88
55–64	1.50 (0.08, 2.92)	2.72 (1.12, 4.32)	2.64 (0.91, 4.37)	1.43 (0.01, 2.85)	0.93
			Women		
25–34	0.88 (−0.55, 2.30)	1.11 (−0.08, 2.30)	2.54 (1.22, 3.86)	1.13 (0.01, 2.24)	0.46
35–44	0.13 (−1.13, 1.38)	0.001 (−1.37,1.37)	1.56 (0.25, 2.87)	1.65 (0.64, 2.67)	0.02
45–54	0.83 (−0.47, 2.14)	−0.42 (−1.72, 0.87)	−1.27 (−2.84, 0.30)	0.88 (−0.10, 1.86)	0.79
55–64	0.93 (−0.44, 2.30)	0.39 (−2.08 – 1.29)	0.76 (−0.68, 2.19)	1.89 (0.76, 3.02)	0.17
			All Ages **25–64**[‡]		
men	1.69 (1.00, 2.39)	2.20 (1.49, 2.91)	2.47 (1.70, 3.24)	1.79 (1.18, 2.40)	0.71
women	0.74 (0.08, 1.41)	0.12 (−0.55, 0.79)	1.08 (0.38, 1.79)	1.40 (0.87, 1.93)	0.04
			p- value for GENDER DIFFERENCES all ages 25–64[‡]		
	$p < 0.05$	$p < 0.001$	$p < 0.009$	$p = 0.34$	

[†] All analyses weighted to be representative of the French population.

[§] SII: Slope Index of Inequality; CI: Confidence Interval

[‡] Adjusted for age as a continuous variable and education in 6 categories.

Table 6

Analysis restricted to those born in France.†

Age	Inequalities related to EDUCATION			Inequalities related to INCOME		
	1991	2003		1991	2003	
	SII (95% CI) §	SII (95% CI) §	p*	SII (95% CI) §	SII (95% CI) §	p*
			Men			
25–34	4.58 (3.18, 5.98)	3.65 (2.42, 4.87)	0.336	4.34 (2.91, 5.76)	2.32 (1.19, 3.46)	0.03
35–44	5.28 (4.04, 6.52)	3.56 (2.49, 4.62)	0.04	3.66 (2.43, 4.89)	2.89 (1.84, 3.93)	0.35
45–54	5.54 (4.06, 7.03)	4.41 (3.35, 5.46)	0.22	3.32 (1.90, 4.74)	3.11 (2.07, 4.16)	0.82
55–64	4.68 (3.22, 6.14)	4.69 (3.41, 5.97)	0.99	4.66 (3.20, 6.12)	3.52 (2.25, 4.80)	0.25
All	**N = 4696**	**N = 7816**		**N = 4348**	**N = 7815**	
			Women			
25–34	2.28 (1.16, 3.40)	2.16 (1.10, 3.21)	0.88	3.08 (1.95, 4.22)	1.69 (0.69, 2.69)	0.07
35–44	3.51 (2.35, 4.67)	2.63 (1.67, 3.59)	0.25	3.31 (2.16, 4.46)	2.53 (1.61, 3.45)	0.30
45–54	4.06 (2.87, 5.24)	3.03 (2.04, 4.01)	0.19	0.89 (−0.44, 2.21)	1.94 (0.99, 2.88)	0.21
55–64	2.03 (0.70, 3.36)	2.62 (1.54, 3.71)	0.49	1.54 (0.18, 2.89)	2.64 (1.59, 3.70)	0.21
All	**N = 5067**	**N = 8675**		**N = 4700**	**N = 8675**	

† All analyses weighted to be representative of the French population.

§ SII: Slope Index of Inequality; CI: Confidence Interval.

* Test of heterogeneity.