Long-term changes of socioeconomic differences in height among young adult men in Southern Sweden, 1818–1968

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Abstract

The study explores the long-term trends in socioeconomic differences in height among young adult men. We linked information from conscript inspections to a longitudinal demographic database of five parishes in Southern Sweden. Detailed information on the occupation and landholding was used to investigate the differences in height. Even if there is indication of a reduction in the magnitude of the differences in height over time the reduction is neither dramatic nor uniform. The most systematic and consistent difference is that sons of fathers with white collar occupations were taller than others. They were 4cm taller than the sons of low-skilled manual workers in the first half of the 19th century, and almost 2cm taller in the mid-20th century. This difference is much smaller than those found between elite and destitute groups historically, in for example Britain, but comparable to that found in other studies on 19th century populations using information on family background. Most of the reduction in the socioeconomic differences in height was a result of reduced height penalty and premium for small disadvantaged and privileged groups. Changes in the distribution of income and the economic structure are plausible explanations for the changes in socioeconomic differences in height.

1. Introduction

Socioeconomic differences in height are found almost universally in studies covering different populations and historical periods (Meredith 1984; Bielicki 1986; Komlos and Baur 2004; Subramanian et al. 2011). The differences indicate the influence of environmental factors on growth, such as nutrition, disease, work and other living conditions (Cole 2003; Silventoinen 2003). It is well established that elite groups were much taller than disadvantaged groups historically (Komlos 2007). Differences found within (almost) complete cross-sections of 19th century populations are most often larger than those found in the 20th century but much smaller than between the elites and destitute groups.[1]

Despite the large number of studies, few explore long-term changes in socioeconomic height differences. Most studies investigate only parts of the 19th or the 20th century (Åkerman et al. 1988), and long-term changes are generally inferred from different samples (Floud et al. 2006[1990]; Costa and Steckel 1997; Sunder 2013) or age groups within cross-sections (Peck and Vågerö 1987; Kuh et al. 1991).[2] The impression from previous studies on the long-term development of socioeconomic differences in height is of declining differences from the 19th to the 20th century. The socioeconomic differences in height found in present day populations also never amount to the 16 cm height differences found between poor and privileged 13 year old boys in England in the 18th and 19th centuries[3] (Floud et al. 2006[1990]; Komlos 2007), or the 9 cm difference Rowntree found between 13 year old boys living in the poorest and

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[1] Studies investigating socioeconomic differences within complete cross-sections, representative samples or similar approaches have found differences in height of 1–8 cm between the shortest and tallest group. Komlos (1994, 495) reports that students at the École Polytechnique were about 4 cm taller than conscripts (who were largely representative of the young adult male population) in France in the early 19th century. Baten (1999, Tab. 6.4) finds that sons of middle and upper class fathers were about 1.3 cm taller than sons of fathers with lower class professions in early 19th century Bavaria. Lantzsch and Schuster (2009, Tab. 5) also investigate data from early 19th century Bavaria and find that sons of fathers who were high ranking officials or had white collar occupations were about 4 cm taller than sons of low-skilled workers and craftsmen. Twarog (1993, Fig. 7.26 and Tab. 7.13) finds that sons of fathers with upper white collar occupations were 4–8 cm taller than sons of fathers who were unskilled manual workers in late 19th century Württemberg. Wilson and Pope (2003) find only small (1 cm) height differences among recruits to the Union Army in mid-19th century USA depending on the occupation of the father. De Beer (2004, Tab. 2) reports that sons of elite fathers were almost 10 cm taller than sons of unskilled workers in Utrecht around 1860. The men had not reached their final adult height at these inspections so some of this height difference is therefore likely to be due to differences in growth tempo. De Beer thinks that the difference in height in adulthood amounted to about 5–6 cm.

[2] A recent collection of results on social differences in mortality indicates that conclusions on long-term trends based on studies of different samples and populations are not always upheld when tested longitudinally within populations (Bengtsson and Van Poppel 2011).

[3] The differences were even larger, 22 cm, at age 16 years (Komlos 2007).

most prosperous areas in York in 1899 (Hatton 2011, 953).[4] Height differences have also been shown to have declined over the 20th century in some present-day high-income countries, especially those with welfare state redistribution policies (Norway: Brundtland et al. 1980; Sunder 2003, Britain: Kuh et al. 1991; Li et al. 2004; Li and Power 2004, Sweden: Peck and Vågerö 1987; Cernerud 1993, see also Rona 2000).

The long-term decline of socioeconomic differences could be the result of a declining level of inequality in the distribution of resources affecting growth, such as nutrition and disease exposure, over time. It has also been suggested in some of the previous writings on socioeconomic differences in height that the extent of the differences will decline with rising income levels, also with constant levels of inequality (Eveleth and Tanner 1990; Moradi 2006; Subramanian et al. 2011). The height of different groups could converge with rising income levels and improving living conditions because of the diminishing marginal product of nutrients and other environmental influences on growth (Martorell and Habicht 1986; Steckel 2008). This would cause a general improvement of conditions influencing growth to increase the height of disadvantaged groups more than the height of privileged groups.[5]

But a direct effect from the average income level on the extent of socioeconomic differences in height gains no support in some empirical tests (Schmitt and Harrison 1988; Van de Poel et al. 2008). There are also many studies that find persistent (Cavelaars et al. 2000; De Beer 2004; Singh-Manoux et al. 2010), or even increasing (Lindgren and Cernerud 1992; Costa and Steckel 1997; Sunder 2013), differences in height despite rising average height and average level of income. A study on Swedish urban schoolchildren born in 1955 is one of a few examples where no socioeconomic differences in height were found (Lindgren 1976). It is less known that significant differences in height reemerged again among boys in cohorts born in 1963 (2.5 cm) and 1981 (0.8 cm) (Lindgren and Cernerud 1992; Cernerud 1994). Others have also shown that the lack of socioeconomic differences in height among Swedes born in the early 1950s was limited to urban populations (Otto 1976, 51; Kihlbom and Johansson 2004). Varying socioeconomic differences in height over time indicate that the magnitude of

[4] The 16 cm height difference corresponds to a difference in height of 2.1 standard deviations for 13 year old boys (World Health Organization 2007). This corresponds to a height difference of about 15.5 cm among adults when adjusting for differences in the standard deviation of height at different ages. Using z-scores does not control for how much of the social differences in height that are the result of growth tempo effects.

[5] For an examples of this see Cernerud and Elfving (1995) or Figure 2 in Li et al. (2004).

the differences is also affected by, for example, the level of inequality in the society (Quiroga and Coll 2000; Monteiro et al. 2010).

Rising income levels have been paralleled with the expansion of redistributive welfare systems in Sweden as well as other countries. This makes it difficult to separate the effect on socioeconomic differences in height from improving living conditions from that from reductions of inequality. A monotonous decline of the socioeconomic differences in height over time would support an effect from improving living conditions in general while height differences that vary over time lend support to an influence from the level of inequality and distribution of resources in society.

This study presents the long-term trends in socioeconomic differences in height among young adult men in southern Sweden. A very long period of time is covered, making it possible to trace the socioeconomic differences in height from the early 19th century pre-industrial setting to the industrialized society with an expanding social security system in the mid-20th century. We can therefore investigate whether the trends in socioeconomic differences in height are dominated by long-term decline or if they vary over time.

Height is influenced by the nutritional status of the mother and by living conditions during childhood and adolescence (Komlos 1989; Ulijaszek 2006). To study differences in 'biological standard of living', as reflected in heights, it is therefore preferable to use information on the socioeconomic status of the family in which the person grew up. In most historical studies the measured individual's own occupation is used to divide them into social classes (Åkerman et al. 1988; Komlos 1989; 1994; Alter et al. 2004). The socioeconomic differences found when using the measured individual's own status are not only a result of differences in standards of living during childhood and adolescence but also include selection effects and influences from living conditions during the late adolescent growth.

Socioeconomic status is measured by the occupation and landholding of the father at the birth of the conscripts. The socioeconomic differences in height investigated in this study are therefore mostly a result of differences in living conditions during childhood even if it is also possible that differences in living conditions of previous generations influence differences among the men (Golden 1994; Young et al. 2008; Özaltin, Hill, and Subramanian 2010). Growth tempo is also affected by environmental conditions during growth. I cannot separate the effects from achieved growth and growth tempo in my results. This is not a problem for interpreting the height differences as results of differences in living conditions. Growth tempo effects could contribute to increasing the measured socioeconomic differences and this should be kept in mind when interpreting the results. The sample size is quite small but we can carry out the analyses within an ethnically homogenous and geographically concentrated population over time using the same data source. The complete cross-section of the sampled population whose social structure is known is included.

2. Methods

The data used come from the Scanian Economic Demographic Database (SEDD; Bengtsson et al. 2012). The SEDD is a longitudinal demographic database covering the population in five rural parishes in southern Sweden from the 17th to the 20th century. It includes all demographic events as well as information on, for example, landholding and occupation. We have now linked information from conscript inspection lists to the SEDD for men born between 1797 and 1950 who were examined between 1818 and 1968 (Öberg 2014). The men included in the sample lived some part of their life in any of the five parishes, Kävlinge, Hög, Kågeröd, Sireköpinge, or Halmstad. The populations in Kävlinge, Hög and Kågeröd are included for the full time period. The populations in Sireköpinge and Halmstad were not yet included in the SEDD for the time after 1895 when the data was collected.

Scania, where these parishes are located, is the southernmost part of Sweden and is dominated by fertile agricultural land (Quaranta 2013). The parishes are all situated some 10 kilometers inland from the western coast and 10–30 kilometers from Landskrona, Lund and Helsingborg which are the closest towns. Starting from c.1865 Kävlinge, and partly also Hög, developed into a small town with some industries and a railway station. The sample is divided into four periods based on the years of birth in order to investigate the changes over time. The periods are based on characteristics of the data and on the economic development in the area. The men born in the first period, 1797–1860, grew up during the transformation of the agricultural economy and early industrialization. The cohorts born in 1861–1910, World War I and the interwar period experienced the industrial expansion and early welfare reforms. Men born in the last period, 1931–1950, grew up in a time of rapid economic growth in Sweden and the gradual emergence of a modern welfare society.

The economic growth and transformation resulted in generally improving living conditions for the population. Real wages in southern Sweden were relatively stable until c.1860 and then increased throughout the rest of the 19th century and first decades of the 20th century

(Bengtsson and Dribe 2005; Lundh 2008). The generally improving conditions in the population are also mirrored in a nearly linear increase in the height of conscripts, for men born from the second quarter of the 19th century onwards (Figure 1). The national trend for the early 19th century comes from published aggregate statistics based on the height of the men accepted as conscripts and is thus biased because of truncation (Hultkrantz 1927). The tables in Hultkrantz (1927) include both a median and an average for each year. Both measures are somewhat upwardly biased because heights are missing from the lower end of the distribution, but the median less so than the average. The trend of the median should also be an accurate representation of the trend of the true mean given unchanging levels of truncation, but not of its level (Komlos 2004, 163). Figure 1 therefore includes the median height for the national series for men born 1819–1906. For men born from 1907 onwards, the measures are averages and are no longer biased. The average height of the men in the five sampled southern parishes was estimated per decade of birth using truncated regressions adjusting for the shortfall in the distributions. The men in southern Sweden were shorter than the national average until the mid-19th century but then caught up almost completely. Part of the difference in height in the early 19th century is likely to be due to the upwardly biased national estimates.

[Figure 1 about here.]

The conscript inspections were organized in a similar way throughout the studied period (Öberg 2014). It always included a physical inspection and a measurement of height. The men were then either accepted as conscripts or freed from duty if they were deemed unfit. There were minimum height requirements (MHRs) for being accepted as conscripts but our dataset also includes some of the heights below the minimum height requirement. The distribution of the heights and the estimation procedures are described more fully in the methods section. A final sample of 4809 men had information on socioeconomic background. 4158 had height measurements, and were taller than the minimum height requirement.

3. Measures of socioeconomic status

The tallest groups historically have been small privileged groups such as the aristocracy (Komlos 2007). Self-sufficient farmers and other groups with good access to food sources have also repeatedly been found to be taller than others (Komlos 2003). In pre-industrial societies, before technological development and societal change improved possibilities for transportation and market integration, it was an advantage to have direct access to food so that farmers were as tall as children of upper class parents. In 19th century Bavaria, for example, sons of farmers were sometimes on average almost as tall as sons of fathers with high ranking white collar occupations (Lantzsch and Schuster 2009). Farmers were also among the tallest in the US during the 19th century. But the socioeconomic background of the tallest group changed over time and in the US the farmers were joined and superseded in height by men with upper class occupations from the middle of the 19th century (Sunder 2013).

It is likely that the taller stature of children of farmers in the 19th century is a result of these families having better or more stable access to food. Previous research on the SEDD has shown that the family's access to land was important for the survival chances of their children in the 19th century (Bengtsson and Dribe 2010). The largest difference in economic and social conditions between groups of landholders with different tenure in the early 19th century was between tenants on manors as compared to other groups of landholders (Dribe 2000; Bengtsson and Dribe 2005; 2010). This difference is used here to separate landholders also based on their tenure.

We divide the families into three categories with regards to landholding; landless, small-scale and large-scale landholders (Bengtsson and Dribe 2005; 2010). The large-scale landholders include landholders who were able to produce a stable income from farming and also to market the surplus production. The group includes freeholders[6] with enough land to be self-sufficient, some nobility, and tenants with large amounts of land (≥0.5 "mantal"). Landholding was measured in a taxation unit called "mantal", based not only on acreage but also the productive potential of the land. The amount of land needed to be classified as a self-sufficient farmer is 1/16 of a "mantal".[7] Freeholders with only small plots of land, tenant farmers without large amounts of land, and crofters are classified as small-scale landholders. This group had to complement their farming income and is not likely to have produced much surplus.

We include measures of both occupational category and landownership of the families in the analyses. The occupational measure implies that different occupations were associated with different levels of income and thus living conditions of the family. The measures of

[6] The freeholder category also includes crown tenants and tenants on church land because their conditions were more similar to the freeholders than the manorial tenants.
[7] One sixteenth of one "mantal" corresponded on average to approximately 6 hectares in Scania in the beginning of the 19th century (Bengtsson and Dribe 2005, 352).

occupational status used here are based on the historical class scheme HISCLASS (Van Leeuwen and Maas 2011). HISCLASS allocates occupations to twelve different levels according to the economic sector, level of skill and supervision, and whether it is a manual or non-manual occupation. It has been created to do this in a way that is comparable over time, making it useful for historical analyses. HISCLASS is based on the 1965 *Dictionary of Occupational Titles*. The classification in HISCLASS is used to create the four occupational groups analyzed here; white collar occupations (including also professionals and managers) (HISCLASS 1–5), farmers (HISCLASS 8), craftsmen (HISCLASS 6–7) and low-skilled manual workers (HISCLASS 9–12).

The socioeconomic status of the father or head of household at the birth of the men is used in the analyses. Men and families moving into the parishes before 1896 have been traced to their parish of origin to collect information on the socioeconomic status of the father at the birth of the children. This reduces any potential bias from differences in migration patterns between socioeconomic groups. If the father's occupational status is missing at the birth, the first available observation before the inspected man's fifth birthday is used where available. Often more than one observation on occupation is available from the same point in time. The highest ranking observation is then used in the analyses. Each son is assigned the status his father had at his birth. The socioeconomic status of the father is in most cases the same for all sons but varies for about ten percent of the families. Information on the occupation and/or landholding of the father is missing for some of the men. Men are included in the analyses if there is information on either occupation or landholding. Missing information on father's occupation is included as a separate category in the models.

The social structure of the population changed with industrialization and economic development (Table 1). About forty percent (36–51%) of the fathers had manual occupations requiring low levels of skill. The relative size of this group decreases from the first to the second period but then increases from the late 19th century onwards. The groups of fathers who were craftsmen or had white collar occupations were always small but increased markedly in relative size over time. The most dramatic changes over time were for farmers and in the landholding. Thirty-three percent of the fathers were farmers in the early and mid-19th century. The size of this group declines in the second period and declines further with each period. Parts of this decline can be explained by the change in the sample frame after 1895. Sireköpinge and Halmstad remained largely agricultural areas in the 20th century but are not included for that period in the sample here.

The landholding also changes considerably over time (Table 1, panel b). Some of this change is similarly due to the changing sample frame, but some is also due to changes in social structure. An absolute majority of the households had access to some land in the early and mid-19th century, and only about one quarter of the families were landless. Most families then only had access to very small amounts of land. Landownership was very unequally distributed (Lee et al. 2009, Fig. 4.1). The landless category increased to 61% of the fathers in the second period because of a large decline in small-scale landholding. The share of large-scale landholders, in contrast, increased slightly between the first and second period but then start to decline. Only a very small fraction of the families had any land in the mid-20th century. Landholding status is unknown for a large proportion of the families in the last period. This is probably due to changes in the system of taxation and the landholding records. It is reasonable to assume that most families with unknown landholding status were landless and they are included in the landless category in the regression models. Including them as a separate group in the regressions did not change the results.

[Table 1 about here.]

4. Statistical analysis

The differences between families were investigated using truncated regressions estimated by maximum likelihood.[8] The models include socioeconomic variables, the period dummy variables used to investigate differences between periods, decade of birth, a dummy variable indicating hired soldiers in the Provincial Army and volunteers for early enlistment, an indicator of men not born in the parishes and of men born in Halmstad or Sireköpinge, and the age of the inspected man centered on the age for compulsory inspection.

The age of conscription was 21 years from 1818 until 1914. For some years in the early 19th century the compulsory inspection wasn't carried out until the year the men turned 22 or 23 years. The age for compulsory inspection was lowered to 20 years in 1914, to 19 years in 1949, and to 18 years in 1954. The inspections were held in spring during the 19th and most of the 20th century. Over 90% of the men were inspected at approximately the same age regardless of their socioeconomic background.[9] We still control for age by including the

[8] The regressions were estimated using the command 'truncreg' in Stata 13.1.
[9] The only men inspected at other ages were the hired soldiers and volunteers for (earlier) conscription. We include a dummy variable indicating these men. The effect of this dummy variable is allowed to vary for the

deviation in age for each man from the compulsory age for inspection. The effect of this linear age variable is allowed to vary over the analyzed time periods.[10] The changing age for inspection and, hence, reference category in the models should be kept in mind when interpreting the results.

The height measures were taken in feet and "verktum"[11] (2.4741 cm) until 1863 (birth cohorts 1797–1842). Between 1864 and 1886 (birth cohorts 1843–1865) the measurements were taken and stated in feet and "decimaltum"[12] (2.969 cm). From 1887 onwards the measurements were taken and stated in centimeters. Until 1863 (birth cohorts 1797–1842) the minimum height requirement (MHR) was 5 feet 5 inches, corresponding to 65 inches ("verktum") or 160.816 cm (Arbo 1875, 12; Hultkrantz 1927, 7f). The MHR for 1864–1886 (birth cohorts 1843–1865) is unknown but from the height distributions it seems to have been similar to that before 1864 at 5 feet 4 inches, corresponding to 54 inches ("decimaltum") or 160.326 cm. From 1887 onwards the MHR was 157 cm but differed between branches of the military (Hultkrantz 1927, 9). Some shorter men were also accepted for unarmed service in the 20th century.

The inspection lists includes height measures for the men who were accepted for conscript training and for those temporarily rejected. Between 1821 and 1860 men who were shorter than the minimum height requirement but otherwise fit were temporarily rejected and had to appear for inspection again in the following (up to four) year(s). Even if there is no clear truncation, the distributions of the data show that heights are missing from the lower end of the distributions (Figure 2). From 1887 onwards the inspection lists include a height measure for (almost) everyone. There are no signs of heights systematically missing from these distributions (Figure 2, panels c and d).[13]

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different time periods. Men who were hired soldiers were exempted from conscription. Some of these men were still found in the conscript inspection lists but this then only included a notation of them being hired soldiers. Heights of the hired militaries were looked for in the database "Skånska Knektregistret", including information from the inspections of the Provincial Army, but not all these men were found.

[10] Controlling for age, as expected, does not change the estimated socioeconomic differences much. A quadratic term for age was included in preliminary analyses but was never statistically significant and did not change the results.

[11] 12 "verktum" = 1 foot.

[12] 10 "decimaltum" = 1 foot.

[13] There are too many (15-20) observations with a height of 174 cm and too few with a height of 178 cm among the men born 1866-1881. This could be due to chance but is most likely a result of mistakes during the data collection.

Because of the shortfall at the lower end of the height distributions we use maximum likelihood regressions to account for this partial truncation (Komlos 2004). Truncated regressions use only the heights above the minimum height requirement. The truncation points used in the models are just below the minimum height requirements.[14]

We also tried restricting the standard deviation of the height variable to be 6.8 cm for the truncated regression as suggested by A'Hearn (2004). Preliminary analyses showed that the results change very little when we apply this restriction and the patterns of the results are exactly the same.[15] The unrestricted standard deviations of the models are plausible and vary between 6.1 and 6.2. The standard errors in the models are adjusted for heteroskedasticity and clustered at the family level.

5. Results

5.1 The socioeconomic differences in height in the population

The socioeconomic differences calculated from the regressions are presented in condensed form in Table 2.[16] The models were estimated using the full sample covering all four periods. The three panels in Table 2 present results from only one regression each all including the same set of control variables. All control variables were allowed to have different effects in the different time periods. The first regression included (besides the control variables) only the occupational variables (panel a), the second only the landholding variables (panel b) and the third both occupational and landholding variables (panel c). The tables report the difference of the groups' average height as compared to the reference category. The estimates presented for periods 2–4 are combined coefficients from the regression. The table also shows the results for the age deviation from the age for conscription, indicators for men not born in the parishes and for men born in Halmstad or Sireköpinge, and for volunteers and hired militaries.

There were socioeconomic differences in height in the population at all times (Table 2). In general the occupational category of the father had a greater impact on the height of the sons

[14] The truncation points used were: for men born 1797-1842, 160.5 cm; men born 1843-1865, 160 cm; men born 1866-1950, 156.9 cm. We estimate the models using the whole sample at once and therefore convert all height measures, and minimum height requirements, to centimeters.
[15] The coefficients and combined coefficients changed by at most 12.7% when applying the restriction.
[16] Table 2 includes only summarized results. The complete results from the regressions are available on request.

than the landownership status also in the early and mid-19th century (Table 2, panels a and b). The occupational measures result in larger and more statistically significant coefficients. The effect from the occupational category on the 'biological standard of living' was also largely independent of the families' access to land. The coefficients for the occupational categories change only slightly when also controlling for landholding status (Table 2, panels a and c). The effect from landholding also changes only slightly when occupation is added to the model (Table 2, panels b and c).[17]

The most consistent result is that sons of fathers with white collar occupations were on average taller than others. The sons of fathers with white collar occupations only make up 5% of the sample in the first period but the group increase in size over time. Most of the fathers in the white collar group had manual occupations as well, or were farmers with an additional occupational title. The most common occupations placing the fathers in this category are parish clerk, farm supervisor, sheriff, or merchant. Most of the fathers (63%) in this category had access to land in the first period and about one-quarter in the second. But the difference in height between men with manual and white collar family backgrounds was largely independent of landholding. These upper class families could secure high enough incomes to provide good conditions for the growth of their children. The consistent height premium for sons of fathers with a white collar occupation supports the view that the manual/non-manual divide between occupations was as important in the 19th as in the 20th century even if the height premium is reduced over time (van Leeuwen and Maas 2010, 434). The size of the coefficient in the mid-20th century, +c.1.8 cm, is comparable to the manual/non-manual (own occupation) height difference found among the older groups in the Swedish 1981 cross-section analyzed by Peck and Vågerö (1987).

The lowest status group, sons of fathers with manual occupations requiring low levels of skill, was not the shortest in the 19th and early-20th century. The sons of the craftsmen were actually shorter.[18] The negative coefficient is very large for the first period, c.-4.5 cm, but could be due to outliers in the data or to the estimator used[19]. The safe interpretation is that

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[17] Because the coefficients don't change much when controlling for both occupation and landholding at the same time compared to when estimating the effects separately there is no indication of problems with multicollinearity.

[18] Twarog (1997) and Lantzsch and Schuster (2009) find similar results for 19th century Württemberg and Bavaria.

[19] The large negative coefficient is statistically significant also when estimating bootstrapped standard errors (The bootstrapped standard errors were estimated with 50 replications with the observations, N=4158, sampled

sons of craftsmen were shorter than others but by an uncertain amount.[20] Sons of craftsmen also only constitute 5% of the sample in the first period.[21]

The skilled fathers worked, for example, as tailors, blacksmiths, millers, or carpenters. In the 20th century they were also, for instance, butchers and shoemakers. The less skilled group consisted of farmhands and laborers in the 19th century. With industrialization in the area, several of these lower skilled fathers also worked in the leather and sugar factories in Kävlinge. The income premium for the skilled workers was apparently not large enough in the 19th century to make the 'biological standard of living' in these families better than among those with lower skilled fathers. A closer relationship with the agricultural sector in the lower skilled group in the 19th century is a possible explanation for the taller recruits of this group (Komlos 1989). Approximately half the craftsmen had access to small or large amounts of land in the first, and about one-quarter in the second, period. The height difference of the sons of the craftsmen is unrelated to the landownership status of these families (Table 2, panels a and c). The significant negative coefficient for the sons of the craftsmen gradually changes to a statistically significant positive over time. Industrialization does not seem to have brought any devaluation of the craftsmen's position but rather the opposite (van Leeuwen and Maas 2010, 434). The group of fathers who were craftsmen is small in the first period when the largest difference is found but it increases in size over time.

[Table 2 about here]

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with replacement.). This indicates that the large negative coefficient not is a result of outliers. Monte Carlo simulations show that results from truncated regressions are consistent also when the truncation point is close to the population average but the variability of the estimates increase (results not shown). The truncation point is close to the population average in the first period (Figure 2). Because the sons of craftsmen were shorter than others their group average probably is at or possibly even below the truncation point. It is therefore possible that the large negative coefficient is due to the estimation technique used.

[20] I also estimated ordinary least squares (OLS) regressions using all available height measures, both above and below the minimum height requirement (results available on request). The results from the OLS regressions are biased because of the (partial) truncation of the sample, but in this way I can utilize the information on the socioeconomic background also of men who were shorter than the truncation point. The results are very similar to the ones from the truncated regressions. Sons of craftsmen are still shorter than sons of lower skilled manual workers but in the OLS results the difference is only -2 cm. The largest difference between the tallest and shortest group in the OLS results is 5.6 cm which is in line with the maximal social height difference most commonly found in previous literature (see footnote 1).

[21] Another possible explanation for the negative coefficient for sons of craftsmen is that they were migrants from the towns in the area. They could constitute an unusual group in being urban-to-rural migrants. Growing up in a town was associated with living conditions that were less beneficial for growth. We tested this by interacting the indicators for sons of craftsmen with the indicators for migrants (results not shown). The interactions were never statistically significant or substantively significant and do not change the interpretation. There is thus no indication that the shorter stature of the sons of craftsmen can be explained by them being born in towns in the area.

Sons of large-scale landholders were c.2.5 cm taller than sons of landless fathers in the first period (Table 2, panel b). The positive influences from being born to a large-scale landholder on the height of the sons remain in all periods but decline in size over time and the difference is not statistically significant. This is what could be expected with increasing agricultural productivity, rising real wages and improved markets for food. As discussed above, it was an advantage in pre-industrial societies to have direct access to food instead of having to rely on market transactions. With increasing surpluses, improved possibilities for storage and transportation and a rising share of the population depending on buying food it became less of a disadvantage for the landless population. Also the sons of small-scale landholders were taller than others, c.1.5 cm, in the first period but the difference is only statistically significant at or close to a 10% level. The coefficients for small-scale landholding vary over time. The coefficient is large and statistically significantly negative (c.-1.5 cm) for the men born in 1911–1930 and the coefficient is negative also for men born in 1931–1950. There was a concern for the standard of living of the small-scale landholders in Sweden at this time but the size of the group in the sample is small so the large coefficients could be a result of random variation.

The amount of land needed to be classified as large- and small-scale landholder is set at the same level in all time periods. The increases in land productivity should therefore work to increase the positive influence from landholding over time. This consequently reinforces the result that the importance of landholding was reduced over time. The incomes of farmers were dependent on their access to land. Having access to land still might have been more important for farmers than other groups when tested with interactions but the sample is too small to allow for including all relevant interactions (results not shown).

Bengtsson and Dribe (2010) studied infant and child mortality in the same population as considered here. They found that the association between the families' access to land on the risk of child mortality was strengthened over the 19th century. The landless and small-scale landholders, had a significantly higher risk of losing a child than did large-scale landholders in the second half of the 19th century. The sons of landholders are also taller in the second, corresponding, period, but only slightly and not significantly so. Height and mortality must therefore reflect somewhat different aspects of health status. This indicates that the interactions between nutrition and the vulnerability to infections are not strong enough to always make average height and mortality levels change in parallel for populations. Another sign of this is that despite the socioeconomic differences in height found here, there were no detectable socioeconomic differences in adult mortality in the population until the last period (Bengtsson and Dribe 2011).[22] Socioeconomic differences in mortality hence emerged when differences in height were declining. Higher incomes and more secure access to food could influence height but had less influence on the risk of dying from for example acute infections.

At least some of the men were still growing at the time of inspection. This can be seen by the always positive coefficients for age (Table 2). The men were becoming on average c.0.8 cm taller per year in the first period, even around the average age of 20.9 years. The onset of the increasing secular trend in height was accompanied by earlier maturation. The coefficient for age is lower in the second and third periods even though the average age of inspection was lower than in the first period. As the age for inspection was lowered over time the share of men still growing increased again and the coefficient for age increase in size again. The men inspected in the last period were on average 18.6 years at inspection. They were still growing, becoming on average c.0.9 cm taller per year (statistically significant). Men born outside the five parishes were not of different height compared to others. The coefficients vary between -0.5 and +0.7 cm but is only statistically significant in the last period. Men born in Halmstad or Sireköpinge were shorter than others in the first period but not in the second (not statistically significant).[23]

6. Discussion

There were socioeconomic differences in heights in the studied population at all times. The average height still increased similarly, by about 12 centimeters, among all men in the studied population regardless of their socioeconomic background (Figure 4). There are, for example, only minor differences in the secular trends of sons of lower skilled manual workers and farmers. That the secular trend was so similar in all groups shows that everyone got some share in the improving conditions over time. This point to the most important determinant of the height increase being the economic growth, the disease environment or something else

[22] The height differences found here are too small to have contributed in any measureable way to the socioeconomic differences in mortality through the association between height and mortality (Floud et al. 2011).

[23] Hired militaries and volunteers for earlier conscription were about the same height as other men in this population, but the height difference varied over time. In the early and mid-19th century they were the same height as others (Table 2). Among men born in 1861–1910 they were 0.9 cm taller. This group made up 9% of the sample during this period. The greatest difference was among men born 1911–1930 when they were almost5 cm taller than others. The group is very small, consisting of just 20 men, so we should not make too much of this large coefficient. The height difference declines again in the last period (+0.9–+1.4 cm) and the group remains small. There is no association between the share of men in the population who were hired soldiers or volunteers, and the height difference.

that affected everyone. I do not think that we can rule out incomes and access to foodstuffs being important for determining the secular trend or socioeconomic differences in height despite this. If calories were relatively equally distributed, which we have reason to believe, and everyone got a share of increasing products, this could lead to largely parallel trends in different groups.

[Figure 4 about here.]

The magnitude of the socioeconomic differences in height found here for the 19th and early-20th centuries amount to approximately 1–c.5[8.5] cm depending on the groups compared. This is comparable to what has been found in other similar historical studies of populations in other European countries (1–8 cm, see footnote 1).

The magnitude of the socioeconomic differences in height was similar in the different time periods. It is only the influence from being born to a landholding family or a craftsman that change statistically significantly over time (results not shown). Most of the historical decline of socioeconomic differences in height shown in this study was a result of a reduction in the differences in living conditions between the relatively small most disadvantaged and privileged groups. Differences in height between wider segments of the population, such as farmers and low-skilled manual workers, were not very different in the 19th compared to the early 20th century, amounting to 1–2 cm. The differences found for the mid-20th century are also comparable to other contemporary populations but smaller than those found in, Great Britain and Poland (Kuh et al. 1991; Bielicki and Szklarska 1999; Mascie-Taylor and Lasker 2005).

The pattern of the socioeconomic height differences in the 19th century is also similar to 20th century patterns in that the manual/non-manual divide, which has been found to be associated with differences in height among children in the 20th century (Lindgren & Cernerud 1992; Bielicki and Szklarska 1999; Mascie-Taylor and Lasker 2005), was similarly associated in the 19th century.

The magnitude and importance of the differences varied between time periods. Wage inequalities increased in Sweden from 1870 until c.1930 after which a drastic leveling sets in (Söderberg 1991; Waldenström 2009). The changes of the differences in height suggestively follow a similar pattern but the changes are not statistically significant (results not shown). The two most important changes of the socioeconomic differences in height over time are those of the trend of sons of craftsmen and the changing influence of landholding. Sons of craftsmen went from being a deprived to being an advantaged group. The position of the craftsmen changed with industrialization which seems to have brought improved possibilities for specialization and/or rising rewards for their skills. The positive influence from landholding on the standards of living in the family was strong in the early and mid-19th century but later quickly lost its importance. Owning your own land was no longer important when the economy diversified, real wages and employment opportunities outside agriculture increased, and markets for foods improved. The results in this study show that socioeconomic differences in height changed over time both in magnitude and with regards to what group enjoyed a more advantageous position in the economy.

[Figure 3 about here.]

Swedish society underwent dramatic changes during the 150 years studied here. Parts of the studied area, Hög and Kävlinge, also experienced some industrialization but the towns remained small and the results of this study reflect the socioeconomic differences in what is, from an international perspective, a largely rural population. This could of course affect the generalizability of the results, but the results are very similar to what has been found in other studies.

One has to keep in mind that occupation does not measure income perfectly. Different aspects of the socioeconomic status of the parents, such as occupational status, level of education, and place of residence, are interrelated and all contribute to differences in height (Wingerd and Schoen 1974; Bielicki et al. 1981; Peck and Lundberg 1995; Silventoinen et al. 2001; Mascie-Taylor and Lasker 2005; Subramanian et al. 2011; Richmond et al. 2013). All aspects of net nutrition are therefore plausible explanations of the socioeconomic differences in height found in this study: the quality and quantity of food consumed, hygiene and disease, working conditions and other aspects of living conditions during childhood and adolescence. The causes of the differences might also very well have changed over time.

Measured differences in height among still growing individuals are the result of a combination of growth and tempo effects. The same factors that reduce growth also tend to delay it. Some of the socioeconomic difference in height presented here are likely to be results of social differences in growth tempo. The shorter, lower status groups probably continued growing for a longer period, making up for some of the differences observed here. These growth tempo effects can be expected to be negatively related to the share of the men who had reached their final adult height. We should therefore expect the growth tempo effects to be largest in the periods when the effect from age is strongest in the regression results. This further enhances the impression of no clear monotonous trend in the magnitude of the socioeconomic differences in height in the studied population. The effect from age is, for example, weaker in the third period than in the second. Still, the measured socioeconomic differences in height increase from the second to the third period. The age for conscription was lowered over time and this meant that a larger share of the men was still growing at inspection in the last period. This can be seen in the results since the coefficient on the control variable age becomes statistically significant in the last period. Some of the already quite small height differences found in the last period could therefore also be a result of growth tempo differences.

The strengths of the study are that the height differences can be studied in the complete cross-section of the population using the same classification of socioeconomic family background while covering a very long time period. There are, of course, also several weaknesses. The sample is small, and this limits the ability to detect changes over time. The sample size and relative size of some socioeconomic groups also limits the ability to examine separately small but important groups, such as the nobility or lower skilled white collar workers.

Another factor that is both a strength and limitation of the study is the small geographical area covered. In some ways this is an advantage since it limits the number of confounding factors of the socioeconomic status. However, it is also a disadvantage since it creates the risk of getting a selected sample. The men born during the 19th century could only be found if they lived in any of the SEDD parishes around the age of conscription, age 17–24 years (Öberg 2014). Geographically mobile men were harder to find in the inspection lists than others and there were socioeconomic differences in the propensity to move. Children of freeholder farmers were less likely to move than others (Dribe 2000). This could create a selection problem if the healthier, taller landless groups were not in the sample.[24]

[24] Sons of fathers with white collar occupations were also more difficult to find during the 19th century. The taller than average stature found for this group might therefore not have been valid for all sons of fathers with white collar occupations. Sons of skilled workers were instead found more often than others in the 20th century. The results for sons of fathers with white collar occupations and craftsmen can only be the result of selective migration if shorter sons of fathers with white collar occupations and taller sons of craftsmen had higher propensities to move than others. We could not find any exogenous factor influencing the likelihood of being found that did not also plausibly affect height to study the potential influence from sample selection statistically using, for example, a Heckman selection model.

7. Conclusions

The sizes of the socioeconomic height differences found in this study are comparable to those in other historical studies on complete cross-sections of populations using family backgrounds. The occupational category of the father was a more important indicator of socioeconomic status than landholding except in the early 19th century. The differences found historically, in this paper and by others, are larger (1–c.5[8.5] cm) than differences found in 20th century populations (0.5–4 cm). Even if there is indication of a reduction in the magnitude of the differences in height over time the reduction is neither dramatic nor uniform. Socioeconomic differences in height within complete cross-sections of the population were similar in magnitude and in their social patterns in the 19th and 20th century. The difference in height between sons of fathers with white collar as compared to manual occupations was the most consistent and important height difference, similar to what is found for many 20th century populations. Most of the reduction was a result of reduced height penalty and premium for small disadvantaged and privileged groups. The distribution of incomes and the differences in standards of living changed with economic development improving the conditions for craftsmen and removing the importance of landownership for height. The results here are more in line with that socioeconomic differences in height change as the social and economic structures and resource distribution changes than with the idea that the differences are strongly influenced by the average income level as has sometimes been suggested in the literature.

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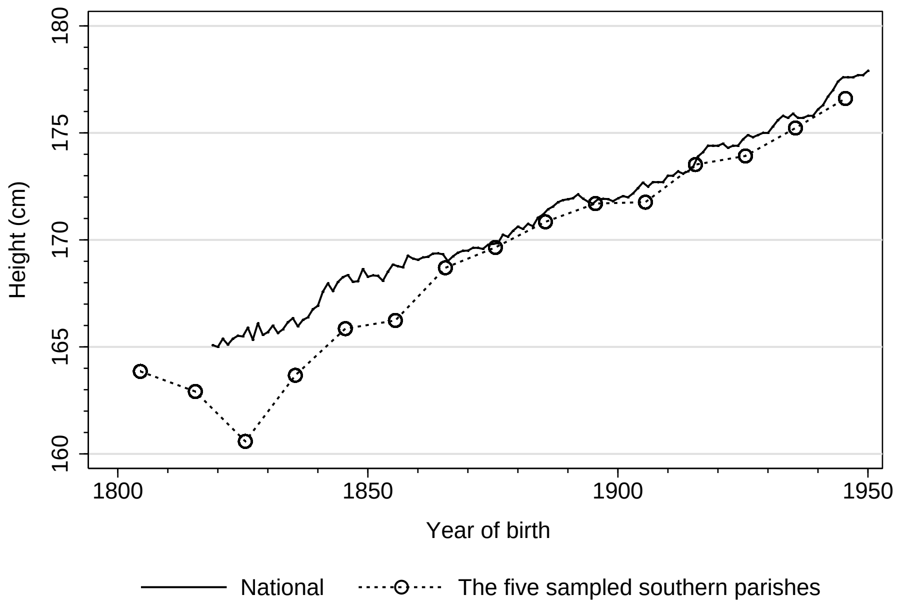
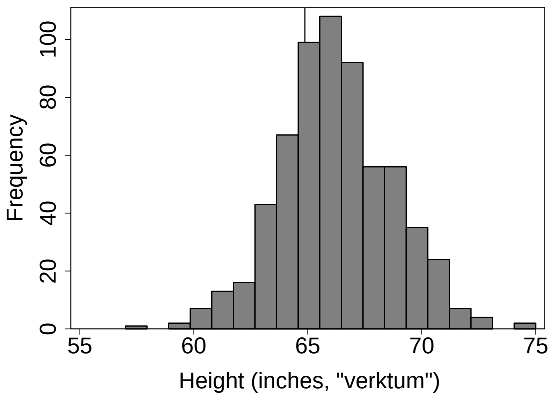
Figure 1 Height of men born 1797–1950, in Sweden and the five sampled southern parishes

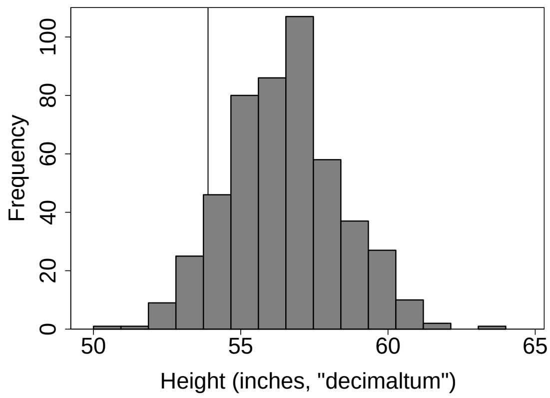


Sources: Sweden: Data from universal conscript inspections. Men born 1819–1906, median height (Hultkrantz 1927, Tables 6, 8 and 11), men born 1907–1910, average height (Kungl. Arméförvaltningens sjukvårdsstyrelse 1931, 19), men born 1911–1924, average height (Statistiska Centralbyrån 1933–1945), men born 1935–1949, average height (Statistiska Centralbyrån 1969, table 1.16), men born 1950, average height (Pliktverket 2000). The average height for the men in the five sampled southern parishes was adjusted for the shortfall and was estimated using a truncated maximum likelihood regression.

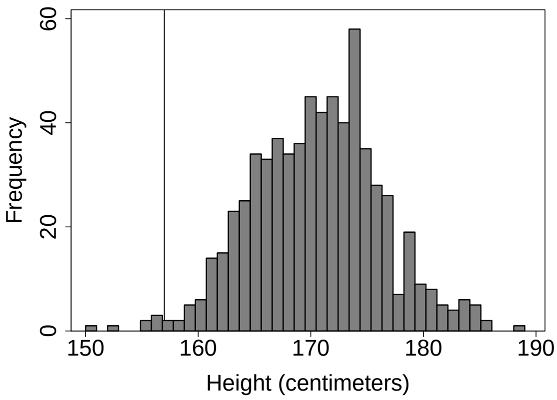
Figure 2 Distributions of heights in the five sampled southern parishes, men born 1797–1950



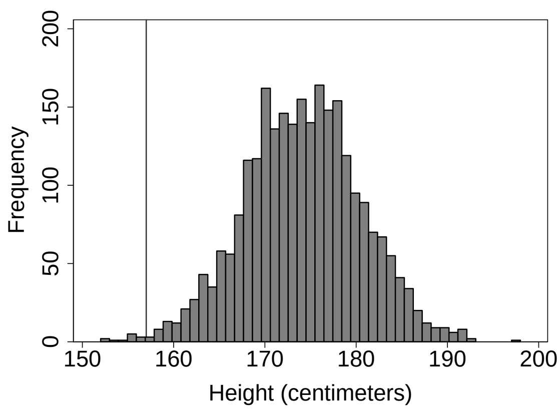
Birth cohorts 1797–1842 (N = 632)



Birth cohorts 1843–1865 (N = 490)



Birth cohorts 1866–1892 (N = 658)



Birth cohorts 1893–1950 (N = 2583)

Note: The vertical lines indicate the truncation points used in the regressions. The periodization for Figure 2 does not follow the one used for the regression analyses. For Figure 2 the sample was instead divided first according to the units used for the measurements and second according to the minimum height requirement. 1 “verktum” = 2.4741 cm and 1 “decimaltum” = 2.969 cm.

Table 1 Socioeconomic family background of the men in the sample (%)

	Years of birth			
	1797–1860	1861–1910	1911–1930	1931–1950
	Occupational category of father			
Low-skilled manual workers	39	36	40	51
Craftsmen	5	12	13	20
Farmers	33	18	16	9
White collar occupations	5	6	10	15
No information on father's occupation	18	29	21	6
	Landholding of parental household			
Landless	24	61	76	53
Small-scale landholding	56	18	6	2
Large-scale landholding	19	21	17	6
Missing information on landholding	0	0	2	40
	Other characteristics			
Age at inspection (years, mean)	20.9	20.2	19.7	18.6
Hired military or young volunteer	5	9	2	2
Not born in parishes	82	58	52	61
Born in Halmstad or Sireköpinge	15	4	–	–
N	1374	1492	894	1049

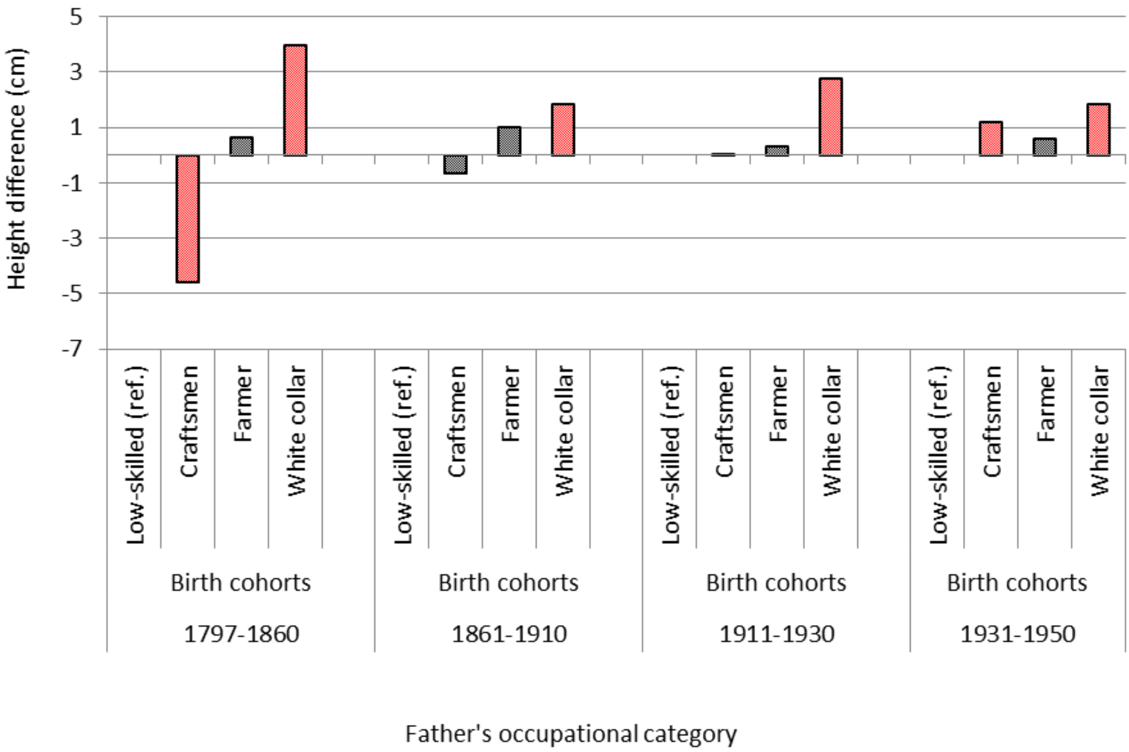
Note: The sample here includes all men as included in the truncated regressions.

Table 2 Socioeconomic differences in height among conscripts in southern Sweden born 1797–1950, results from weighted truncated regressions

Dependent variable: Height (cm)	Years of birth			
	1797–1860	1861–1910	1911–1930	1931–1950
Panel a	**Occupational category of father**			
Low-skilled manual workers	ref.	ref.	ref.	ref.
Craftsmen	-4.6***	-0.7	+0.05	+1.2**
Farmers	+0.6	+1.0*	+0.3	+0.6
White collar occupations	+4.0***	+1.8**	+2.8***	+1.8***
No information on father's occupation	-0.3	-0.1	+0.2	+1.0
Age (years)	+0.9	+0.6	+0.3	+1.0**
Not born in the five parishes	-0.5	+0.4	-0.3	+0.7*
Born in Halmstad or Sireköpinge	-1.4	+0.1	–	–
Hired military / young volunteer	+0.1	+0.9	+4.9**	+0.9
Panel b	**Landholding of parental household**			
Landless	ref.	ref.	ref.	ref.
Small-scale landholding	+1.4*	+0.7	-1.6**	-0.9
Large-scale landholding	+2.6**	+0.8	+1.2	+1.8
Age (years)	+0.8	+0.6	+0.4	+0.9*
Not born in the five parishes	-0.1	+0.6	-0.2	+0.7
Born in Halmstad or Sireköpinge	-1.3	+0.1	–	–
Hired military / young volunteer	+0.4	+0.9	+5.1***	+1.4
Panel c	**Occupation and landholding**			
Landless, low-skilled manual workers	ref.	ref.	ref.	ref.
Craftsmen	-4.4***	-0.7	+0.04	+1.2**
Farmers	-0.1	+0.7	+0.2	+0.4
White collar occupations	+3.6**	+1.8**	+2.7***	+1.9***
No information on father's occupation	-0.9	-0.3	+0.3	+1.0
Small-scale landholding	+1.5	+0.5	-1.4*	-1.0
Large-scale landholding	+2.4**	+0.6	+1.3	+1.9
Age (years)	+0.8	+0.6	+0.3	+0.9**
Not born in the five parishes	-0.5	+0.3	-0.2	+0.7
Born in Halmstad or Sireköpinge	-1.4	+0.1	–	–
Hired military / young volunteer	+0.3	+0.9	+4.7**	+0.9
Number of observations (panels a–c)	1374	1492	894	1049
Number of truncated observations	488	105	37	21

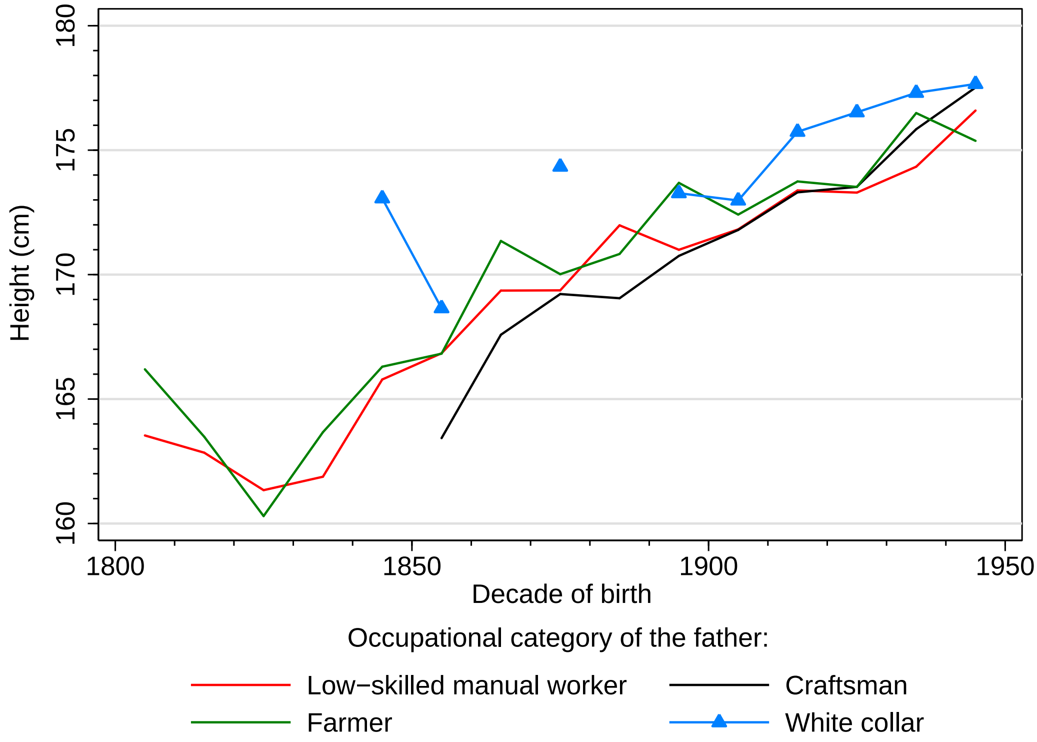
Note: The results in the three panels each come from one separate regression. The presented numbers are combined coefficients for the periods 1861–1910, 1911–1930 and 1931–1950. The estimated standard errors of the regressions (sigma) were 6.15 (panel a), 6.18 (panel b) and 6.13 (panel c) in the three models respectively. Standard errors used for the statistical significance are robust and clustered at the family level (2748 families). Statistical significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Figures in bold indicate that the group's average is significantly different ($p < 0.10$) from the first period (birth cohorts 1797 – 1860). The variables included in the models were the indicators for occupation and/or landholding of the inspected men's family of origin, age, an indicator of whether the man was a hired military or a volunteer for earlier enlistment and an indicator of whether the man was born in any of the five database parishes and one for men born in Halmstad or Sireköpinge. All these variables were allowed to have different influences in the four time periods. The models also include dummy variables for the different periods and decade of birth with relevant exclusions.

Figure 3 Difference in height among conscripts in southern Sweden born 1797–1950 by the occupational category of the father



Note: The underlying data are from the regression in Table 2, panel a. Coefficients and combined coefficients that are statistically significant in Table 2, panel a, are indicated in red.

Figure 4 Socioeconomic group specific secular trends among young men in southern Sweden born 1797–1950



Note: The figure is based on results from truncated regressions estimated for each occupational category separately. The standard deviation of the residuals is constrained to be equal to 6.2 cm which is the estimated value for the full sample. Estimates based on less than ten observations were excluded from the graph.