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HEIGHT, WEIGHT AND BODY MASS OF THE BRITISH POPULATION SINCE 1820

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ABSTRACT

The average height of a population has become a familiar measure of that population's nutritional status. This paper extends the use of anthropometric data in the study of history by exploring published evidence on the weight, as well as the height, of British populations in the nineteenth and twentieth centuries and by computing the Body Mass Index of those populations.

The results confirm a fall in mean height in the middle of the nineteenth century and show that this was paralleled by a fall in weight. Subsequent increases in weight and BMI lagged behind those in height. The data show no evidence of inequalities in nutritional status within families.

Earlier findings of a period of declining height in the mid-nineteenth century have been attacked because of an apparent inconsistency with real wage data. The evidence for decline is now confirmed by further anthropometric and mortality data, while recent research into real wages has confirmed that a check to growth occurred and has thus removed the apparent inconsistency.

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Introduction

The mean height of an human population has long been known to be an indicator of that population's nutritional status, health and strength.[1] For centuries, armies rejected short men who tried to enlist, while in many walks of life height has conferred an advantage on those who possess it.[2] It is only in the last twenty years, however, that historians and economists have used the voluminous evidence which survives about the height of people in the past to explore the nutritional status of historical populations. Despite this recent start, the use of evidence on heights is now well established and studies have been made of many countries throughout the world during a variety of periods of time.[3] There has also been vigorous debate about the utility of measurements of height, about the meaning of the term "nutritional status" when applied to historical populations, and about the relationship between height, nutritional status and conventional measures of changes in the standard of living such as the real income or real wages of populations.[4]

Much of that debate, though couched in the language of history and economics, has been concerned with issues of human biology which have simultaneously attracted the attention of scholars in many of the medical, human and social sciences. Essentially, these scholars debate the extent to which events in early life, the foetal environment, or even the experience of mothers before the conception of their children, as well as events during and after childhood and adolescence, have long-term consequences for the growth, bodily shape, health, productivity and even longevity of human individuals and populations. These debates affect social scientists faced with the task of explaining, for example, the increased lifespan of people in the developed world, since they point to the need to consider the environment of people throughout their lives, rather than simply in older age-groups. [5]

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[1] Tanner 1981.

[2] Floud, Wachter and Gregory 1990; references in Harper 1997.

[3] The most recent surveys of this literature can be found in Steckel and Floud 1997.

[4] See, for example, Gregson and Grubb 1997.

[5] Barker 1992, 1994; Fogel 1997.

The mean height of a group of people is an extremely good indicator of the group's cumulative nutritional status up until the age at which growth in stature ceases; this occurs before the age of twenty today, but during the early twenties in the past.[6] But because growth in height does cease in early adulthood, height data cannot give a "snapshot" of the nutritional status of an adult later in life. This has given rise to criticism of the analyses of height data which have related height to adult occupation or wages. It has been argued, for example, that occupational differences reflected in family incomes can logically affect only the heights of the children of those receiving that income; the heights of the adults cannot change, however much they earn. One counter to this argument is that there was in the past a considerable degree of occupational stability, or at least a lack of significant occupational or class mobility; the occupation of an adult is thus a good indication of the occupation of his or her father. There is no doubt, however, that it would be better to have direct measures of the nutritional status of adults as it changed after the cessation of growth in height.

In *Height, Health and History* we assembled and analysed evidence on the heights of British people since 1750. This paper seeks to bring together and discuss the published British evidence which is available for two further indicators of nutritional status. The first is weight; the second body mass. Both, like height, reflect the balance between dietary intakes and the claims on those intakes made by the needs of body maintenance, work and disease. But, unlike height, measures of average weight and BMI (the Body Mass Index) can reflect nutritional status in adulthood after the cessation of growth in stature.

Weight is, like height, directly observed. However, weight is unsatisfactory as an indicator of nutritional status because of its strong correlation with height; broadly, if people are taller they are thereby heavier and, in childhood and adolescence, weight and height increase together. The correlation is not, however, a perfect one, since among adults height is at first

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[6] It is important to recall, when examining data on height, that height does decline in middle and old age. The rate of this decline does not appear to be affected by nutritional status.

static and then declines after middle age while weight tends to increase with age. For these reasons, calculations of the average weight of a population must take account of, or control for, the average height of the population and the ages of those measured; this is conventionally done by calculating measures of weight for height.

The most commonly used method of doing this is to calculate the average Body Mass Index (BMI) of a particular person or group, the Index being defined as weight in kilograms divided by the square of height in metres. BMI (sometimes known as the Quetelet Index) has the statistical advantage that there is a very low correlation between BMI and height, the cross-sectional correlation coefficient being in the neighbourhood of 0.15; this accords with common sense, since there is, within a given environment, no reason why taller people are more likely to be obese, or short people more likely to be wasted.[7] The low correlation of height with BMI also accords with empirical evidence that some health outcomes are affected by height but not by BMI, some by BMI but not by height. Normal BMI, in the contemporary British population, is considered to be 24-25, with levels of 20 or below indicating significant wasting and levels of 30 or over indicating obesity; in the early 1980s, about 10% of the British male population and 14% of the female were significantly underweight, and 6% of males and 8% of females were obese.[8]

This paper considers the evidence of published sources on changes in the height, weight and body mass of the British population since the early nineteenth century and the conclusions that can be drawn from that evidence,

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[7] Knight and Eldridge 1984

[8] Knight and Eldridge 1984 found (Tables 4.10 and 4.11) that the average value of BMI for the whole population was 24.3 for males and 23.9 for females. For both sexes, BMI rose with age. For males, BMI was 21.4 for the 16-19 age-group, 25.4 for the 60-64 age-group, for females the rise being from 21.9 to 25.7. As they state: “Of course any absolute thresholds will seem arbitrary but it is suggested that those with BMI of 20 or less might generally be regarded as tending to be underweight and people with BMI above 30 could be regarded as obese.

within Britain and in comparison with similar evidence from the USA.[9] It draws on a number of previous compilations of such data[10] and seeks to bring together almost all such sources, but part of its purpose is to stimulate the search for other evidence.

Data Sources and Methods

Historical data on height and weight are consistently less than ideal. No properly designed random sample of the height and weight of the British population was taken until the 1980s and historians are therefore faced with reconstructing estimates from imperfect sources, assembled at irregular intervals. This fact has always to be borne in mind during discussion of these data, but the problem is unavoidable.

The data used in this paper are drawn entirely from published, as distinct from archival, sources. This distinguishes them from the data used in *Height, Health and History* and a number of other studies.[11] At least for periods before the middle of the nineteenth century, data used in those studies were drawn from archival sources which recorded the heights of individuals: the recruitment records of the Army, the Royal Marines and the Marine Society and the records of British prisons and of prisoners transported to Australia. Unfortunately, none of these archival sources systematically recorded the weights of recruits.

A second difference is that the data used in this paper are not observations of the height of individuals, but rather averages of the heights and weights of some or many individuals, compiled in various ways from individual observations by many different authors. The averages presented here for particular age-groups and time periods are, therefore, means of means.[12] For this reason, and because many of the published sources do not

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[9] Costa and Steckel 1997.

[10] Floud, Wachter and Gregory 1990; Rosenbaum 1988; Professor Thomas Jordan has discussed 8 such data sets in an unpublished paper.

[11] Johnson and Nicholas 1997; Floud and Harris 1994.

[12] It follows that the calculations of mean BMI are, to be precise, of mean weight divided by the square of mean height rather than, as would be the case when individual data are

give full details of the methods of data collection which were used, it cannot be assumed that the data constitute representative samples of the British population. In some cases, indeed, the data are drawn explicitly from only one geographical area. However, one large data set of this regionally-specific type, the records assembled by Bernard Harris of the medical examinations of schoolchildren in a large number of areas between 1907 and 1939, has not yet been integrated into the analysis; it is hoped to do this in later versions of this paper.[13] Nor do the data sets necessarily all refer to the same social classes. Last, the original sample sizes varied widely and were not always explicitly stated.

As if these problems were not enough, all data on body size suffer from problems of measurement error. Recruiting sergeants, in the eighteenth century, had to deal with deliberate efforts to falsify height so as to pass the military standards, but a more common problem was that equipment was inadequate for the precise measurement of height; for this reason, height measurements were usually rounded to the next lowest whole inch or half-inch. However, the normal practice was to expect subjects to remove their shoes.

Weight measurements are even more problematical. The equipment required for the accurate measurement of weight is significantly more complex than that needed for the measurement of height; the latter can be as simple as chalk marks on a wall, while machines for weighing people are larger and more expensive. A further complication is that for much of the period modesty forbade the removal of the clothes of many subjects, particularly females, even for quasi-medical purposes; almost all subjects were therefore measured wearing some or all of their clothes. In some cases, the researchers made allowances for the weight of those clothes before reporting their results, in others they state that they did not do so, while in yet other cases no explicit mention is made of clothing.

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available, the mean of a number of individual BMIs. There is no reason to believe that this introduces any bias.

[13] Harris 1994.

In the analysis which follows, any allowances for clothing made by the researcher have been accepted without adjustment, on the assumption that they were in the best possible position to estimate the weight of clothes worn. Where it is apparent that clothes were worn, but no allowance was made for their weight, two alternative adjustments for the weight of clothing have been made, following the methods suggested by two researchers who studied the issue in the nineteenth century. John Hutchinson, in 1846, reported and made use of the opinion of Adolphe Quetelet (1796-1874), one of the pioneers of the study of human growth, that an appropriate allowance for clothes, at all ages, was “one-eighteenth part of the total weight of the male body and one-twenty-fourth part of the total weight of a female.” In 1876, however, another pioneer of the subject, Charles Roberts, stated that an appropriate allowance was 10 lb. (4.54kg). Kemsley, in his study of the British population in 1943, used the same allowance as Roberts for males but allowed 6 lb. (2.72 kg) for females (in both cases including the weight of shoes). Unfortunately, none of these researchers give any adequate justification for these suggested allowances, which produce somewhat different results when applied to the typical weights of the British population in the periods in question, as table 1 shows. In the analysis which follows, therefore, both the Quetelet and the Roberts allowances have been used and attention is drawn to this wherever it is relevant. It is difficult to know whether sufficient allowance has been made for the weight of clothing, but subtracting a greater amount would have led to implausible values for mean weight and thus for body mass.

In total, published sources provide about 1000 observations of the mean height and weight at particular ages of groups of males, the earliest relating to men or male children born between 1810 and 1819. There are about 500 observations of the mean height and weight of groups of females, the earliest relating to women or female children born in the 1820s. As was made clear above, each of these observations is itself a mean of a number of individual measurements of individuals. Table 2 shows the distribution of the number of observations across time periods and by age-group of those measured.

In some analyses, in order to make comparisons on a common basis between different age-groups, each observation for a given age-group has been expressed as a percentage of the modern standard height, weight or BMI for that age group.[14] An alternative, but more complex, method would have been to express each observation in terms of standard deviation units, calculated from the distributions relevant to each age-group, but the results of such normalisation would have been less easy to comprehend and interpret.

It should be remembered, however, that distributions of height, weight and BMI do not have the same parameters. Adult male height is normally distributed with a standard deviation of about 2.5 inches (6.35 cm) while female height is normally distributed with a standard deviation of about 2.2 inches (5.59 cm). Adult weight distributions, however, are positively skewed with standard deviations of about 12 kg (24.5 lb.) for males and 11 kg (22.5 lb.) for females.[15] The distribution of adult BMI is also positively skewed. Because of the different shape of the distributions, a group with mean height 10% below the current British male mean height of 173.9 cm would have a mean height of 156.5 cm, 2.7 standard deviations below the mean, while a group 10% below the current British male mean weight of 73.6 kg would have a mean weight of 66.2 kg, only 0.6 standard deviations below the mean. Similarly, the current mean BMI for British males is 24.3, so a group 10% below that level would have a BMI of 21.87, but the standard deviation of the distribution of BMI is about 3.3, so that the group is about 0.7 standard deviations below the mean. These differences in distributions need to be borne in mind in the interpretation of some of the figures given below.

The final complication which affects the presentation of the results in the next section of this paper is that men, women and children were measured at different ages and different times. Following intense discussion

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[14] For ages up to 18, the modern standard has been taken from Tanner, Whitehouse and Takaishi 1966; for older ages, the standard has been taken to be the results of the sample survey by Knight and Eldridge 1984.

[15] Calculated from information given in Knight and Eldridge 1984.

in the early stages of the analysis of historical height data, it has become customary to organise the data into birth cohorts; as an example, men measured when aged 20 in 1880, and therefore born in 1860, are grouped with men aged 40 in 1900, (and thus also born in 1860), rather than with men aged 20 in 1900.[16] This practice implicitly reflects the fact that, in measuring height, we are dealing with the consequences of events in early life, so that the reference should be to the date of birth rather than to the date, possibly many years later, at which the measurements were made; this ensures that cohorts with different environmental experiences are kept distinct.[17]

It could be argued that this logic would lead to a different treatment of data on weight and BMI, since these reflect partially events and environments long after birth, but the practice of using birth cohorts is so well established that it is followed here for the sake of consistency.

Results

Trends and levels of height, weight and BMI.

The new results which most closely parallel and complement the evidence from individual heights presented in *Health, Height and History* are those for the heights of groups of adult males, shown in table 3.[18] The average heights of the birth cohorts, shown in the final column headed "mean of means" in table 3, show an increase from the birth cohort of 1800-19 to

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[16] See Floud, Wachter and Gregory 1990:132 for a discussion of the distinction between birth and recruitment cohorts.

[17] Gregson and Grubb 1997 criticise some scholars for forgetting, or failing to emphasise, the fact that height reflects childhood events. However, the use of birth cohorts implicitly recognises this fact.

[18] It should be noted that, from the 1830s to 1881, some of the group data - drawn from the published reports of the Army Medical Department, were in fact spliced with the individual data and reported as such in table 4.1 of *Health, Height and History.* The data used in table 3, however, were calculated by Rosenbaum (1988) using somewhat different methods from those used in *Health, Height and History.* Table 3, of course, also uses data drawn from other sources.

that of 1820-39, falling back slightly in the cohorts of 1840-59 and 1860-79, before rising into the twentieth century (although with an apparent fall in the cohort born in the first twenty years of that century). This pattern is similar to that found in the individual height data; in particular, it confirms the decline in the middle of the century which has become the subject of some controversy. The absolute levels found in the group data are, however, consistently higher by some 1-2 centimetres than those derived from the individual data and reported in Table 4.1 of *Health, Height and History*. It seems likely that this stems from the fact that table 3 includes data from non-military sources and thus, to some extent, includes men from higher social groups than the working classes who provided the bulk of army recruits.

Figure 1 presents the data on adult male heights in a different way, by calculating each observation - now for 10-year birth cohorts - as a percentage of the modern British standard; this has been drawn from observations of the relevant age-groups in the past twenty years. Figures 2-4 show similar results for male children, female adults and female children respectively. The decline in male heights, for adults from birth cohorts of the 1820s to those of the 1860s and for children from the 1840s[19] to the 1870s, is clearly shown. While there are less than 10 observations for each of the adult birth cohorts of the 1820s, 1830s and 1840s, the mean heights for those periods are consistently greater- though perhaps too high in relation to the modern standard to be believable - than those for the 1850s and 1860s. The cohorts of the 1870s and 1880s show increased height, but thereafter there is a return to the levels of the 1850s and 1860s, before significant growth occurs between the 1910s and 1920s. Male children also show a substantial decline in mean height between the 1840s and the 1870s, followed, as with male adults, by an improvement and then a renewed decline before improvement occurs again from the 1910s onwards. There are insufficient observations for adult females in the relevant birth cohorts to draw any conclusions, but there is a slight fall

[19] There are no observations for the 1830s.

between the 1860s and 1870s among female children, paralleling that found for male children.

These data collectively show, therefore, a decline in heights in the middle of the nineteenth century, as described in *Health, Height and History*. What is perhaps most surprising is that the recovery from these levels appears to have been more prolonged than was suggested in that book, with a further decline or at least stability at the end of the century. It has to be remembered that there were no army recruitment or other individual data for birth cohorts after 1881, and it is likely that we were misled, in *Height, Health and History*, into an incorrect interpolation between those earlier birth cohorts and the evidence of various surveys in the inter-war period. The implication is that growth in heights was faster, in the period around the First World War, then has hitherto been believed.

The new data make it possible to consider not only height but also weight and body mass, with results for adult males shown in tables 4 and 5. As explained above, there are no comparable data for individuals and these data must stand on their own. It must be re-emphasised that, for the nineteenth century birth cohorts, adjustments for the weight of clothing are significant, as both tables show. The tables do however show increases in both weight and BMI, but these occurred somewhat after increases in height, most significantly in the period after the First World War. It is important to stress that the absolute average levels of height and weight, and of BMI, were significantly less, in the mid- to late nineteenth century, than today. It may not seem very striking to say that men and women were, at that time, only 2-3% shorter and 10-15% lighter than today, but these are large differences by the standards of variations in average height and weight over time and between populations. In the male birth cohort of 1840-1859, for example, men attained a mean height of 171 cm (67 inches) and a mean weight of 68 kg (150 lb.) in adulthood, as compared with current British values of 176 cm (69 inches) and 71.4 kg (157 lb.).[20] A mean height of 171 cm is the same as that attained today by the Bulgarian, Hungarian, Romanian

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[20] Knight and Eldridge 1984, tables 2.1 and 3.1.

and Russian (Moscow) populations, but all but one of these populations, the Romanian, is heavier by up to 4 kg than the British mid-nineteenth century mean.[21] The closest analogue in the modern world to the British male populations of 150 years ago is the modern Romanian population. In other words, the British population of the mid-nineteenth century was both stunted and wasted, but particularly wasted, when compared to the modern British population.[22]

So far as changes over time are concerned, the results of analysis are shown, again as percentages of the modern standard, in figures 5-8 for weights and 9-12 for BMI.[23] The data are consistent with expectation and modern evidence in that both weight and BMI rise with age, as tables 4 and 5 demonstrate for adult males. The new data show that, for males, the decline in mean heights in the middle of the nineteenth century was paralleled, perhaps even slightly surpassed, by a decline in mean weights and that, as an arithmetical result, there was a similar fall in mean BMI. Following this decline, male adult height rose slightly from the birth cohort of the 1860s, but weight remained much more stable or even declined until the end of the century, as it did with adult females. This finding, if confirmed by other evidence, is both surprising and significant. It suggests that, whatever the causes of the improvement in nutritional status after the 1860s which produced increases in height, those factors were not sufficiently strong to induce similar increases in weight. This point is considered further below.

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[21] Eveleth and Tanner 1976

[22] The terms “stunted” and “wasted” are used in their technical sense of “significantly below mean height and weight.”

[23] Tables 3-12 show mean height, weight and BMI attaining values of over 100% of the modern standard, in most cases from the birth cohorts of the 1920s onwards. The most likely explanation for this phenomenon is that the published data sets are drawn predominantly from relatively prosperous groups of the population, or perhaps geographical areas, and that working-class groups are under-represented. It is impossible, given the number of observations and the information available, adequately to control for this difficulty, but there is no reason to suppose that it varies significantly over time.

After the beginning of the twentieth century, the increase in the weight of both adult males and adult females was much more dramatic than the increase in height, and this led to substantial changes to BMI; this was particularly apparent between the birth cohort of 1900-1909 and that of 1930-39, by which latter date modern levels of BMI had largely been attained. There was then possibly a slight dip in BMI in the birth cohorts of the 1950s and 1960s, caused by a slightly greater increase in heights than in weights at that time, but recent indications are that weight and BMI are both increasing, leading to some widely popularised fears of the impact of obesity on health.

The position with children is less clear-cut and is particularly affected in the case of females by small sample sizes. Male child heights and weights appear to have fallen, as with adults, in the middle of the nineteenth century before rising again in the latter years of the century, but the same pattern is not observable for females. For both male and female children, however, it appears that the rise in both heights and weights began during the last quarter of the nineteenth century but was particularly marked between the birth cohorts around the start of the twentieth century and those of the 1930s. Height and weight rose together over those years, giving rise to an upward trend in BMI which was less steep than for adults at the same period, but confused by a sawtooth pattern which may again reflect small sample sizes.

Increase in height and weight during childhood and adolescence is also faster today than it was in the nineteenth century, while growth in height in particular ceases at an earlier age. The numbers of observations at particular ages are too few, among the published data sets, to calculate full growth profiles, but the heights and weights which were attained in early adulthood, around the age of 19, in the male birth cohort of 1840 to 1859 are today attained at the age of 15. Similarly, the average height and weight of men of that cohort in their early thirties is now attained, for height, at the age of 16 and for weight at the age of 21. Differences in physical appearance from today were thus particularly great in late adolescence and early adulthood.

It must always be remembered that average figures, such as those just quoted, are merely a representation of the underlying distributions of individuals' heights, weight and BMI. Unfortunately, the lack of individual observations makes it impossible to calculate the full underlying distributions but it is possible to suggest their underlying shape by inference from modern distributions. This is particularly easy in the case of height, because of the normality of height distributions and the fact that they have a common standard deviation among males of 2.5 inches (6.4 cm). A mean height for the male birth cohort of 1840-1859 of 171 cm (67.3 ins) therefore implies that about 16% of that cohort had a height of less than 164.6 cm (64.8 ins) and that 2.5% of the cohort had a height of less than 158.3 cm (62.3 ins). Inference from modern distributions of weight and BMI is more complex, because it cannot be assumed that historical distributions had the same shape as those of today, but a modern distribution of BMI with a mean of 21.4, a level typical of the younger adult age-groups among mid-nineteenth century cohorts, has 33% of the distribution with a BMI of less than 20, taken to be the current definition of underweight. This confirms the inference that significant fractions of the nineteenth century populations were severely stunted and wasted by the standards of today.[24]

Stunting and wasting within the family

The data do not, however, support the conclusion that Victorian male adults were significantly better nourished, and therefore less stunted or wasted, than women and children; nor do they show that Victorian male children were better nourished than their female siblings. This is surprising, since there is substantial evidence from nineteenth century social surveys and remarks by contemporary observers that, in times of distress, the male breadwinner was protected, receiving such food as was available while women and children went without. Rowntree, for example, stated that:

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[24] If, as suggested in footnote 22, the published observations are biased towards the higher socio-economic groups, this would be an under-estimate of the true extent of stunting and wasting in the whole population.

> "We *see* that many a labourer, who has a wife and three or four children, is healthy and a good worker, although he only earns a pound a week. What we do not *see* is that in order to give him enough food, mother and children habitually go short, for the mother knows that all depends upon the wages of her husband."[25]

One might have expected such a bias to be reflected in the weights and BMI of women and in the heights, weights and BMI of children. It is true that, in the 1860s, both male and female children appear to have been relatively stunted compared with adults; male adults were 3% below the modern height standard and female adults 1% below, while male and female children were respectively 5% and 7% below. However, such comparisons of height are likely to be affected by differential growth velocities, with adults approaching closer to the modern standard than children, at a given level of nutritional status, because they continued to grow for a longer period.

More significant is the fact that there is no apparent difference between the weights (expressed as percentages of the modern standard) of different groups. Again in the 1860s, the average weight of male adults (based on data adjusted for the weight of clothes) was 14% below the modern standard, while female adults were 10% below, male children 13% below and female children 16% below. Furthermore, there was no difference at all in BMI between men and women, both being 9% below the modern standard, while children apparently did better, with males 3% below and females 5% below. Finally, the pattern of change in male and female child heights and weights is very similar.

It would be foolish to dispute, on this flimsy basis, the weight of historical and, indeed, contemporary evidence of bias in the distribution of resources within the household. It is certainly difficult to do so without much more quantitative evidence than is ever likely to be available of the "coping strategies" used by nineteenth century families in the face of poverty. The

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[25] Rowntree 1901:135.

evidence of heights and weights could be reconciled with observations such as those of Rowntree by hypothesising that women and children compensated for low nutrient intakes by reducing their levels of work or their play activity, thus maintaining an equivalent net nutritional status to that of their menfolk. But such an hypothesis sits ill with descriptions of the life of working-class women or with the knowledge that even towards the end of the nineteenth century children sought paid employment long before the end of their period of physical growth. All that one can say is that these new data do not support the suggestion that there were gross inequities in the division of resources within nineteenth century households.

Mortality, morbidity and productivity

Significant research effort has recently been devoted to understanding the relationship between early life experiences, and particularly nutritional status, and chances of morbidity and mortality at later ages.[26] Particular attention has been paid to a survey of the Norwegian population, including measurements of heights and weights, which has been linked by Waaler and his colleagues to information about the subsequent mortality of the population; this has made it possible to calculate the chances of death from particular diseases associated with different heights, weights and BMIs. Fogel and Kim have transformed the data first analysed by Waaler into tables which allow the calculation of the probability of death in certain age-groups for those of particular heights and weights and have suggested that these tables can be used to explore the increased mortality, compared with modern levels, which can be attributed to levels of heights, weights and BMIs in the past. This technique has been used, for example, by Costa to explore the consequences of the low weights and BMI of Union Army veterans.[27] “Had it been possible to shift the BMI distribution of Union Army veterans one standard deviation to the right so that the mean would be equivalent to that

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[26] See, in particular, Waaler 1984 and Barker 1992 and 1994.

[27] Costa 1993.

prevailing in modern Norway, the implied 14% reduction in the mortality rate would explain roughly 20% of the total decline in mortality about age 50 from 1900 to 1986,..."[28]

Can similar statements be made about the British populations of the mid-nineteenth century? As table 6 shows, the increased risk of death, above the contemporary Norwegian levels applying to males aged 50-64, and attributable to the lower average heights and weights of the British, was as much as 16% in the most directly comparable figure, that for 61-70 year olds born in 1860-1879. However, table 6 also shows that almost all the other observations of average height and weight yield estimates of heights above 170 cm and BMIs which range between 22 and 25; most of the cohorts therefore have much lower relative risks, between 85 and 100% of contemporary Norwegian levels.[29]

These levels of BMI appear to be comparable to those found at the same time in the United States and derived from the Union Army records; Costa and Steckel report, for example, that the BMI of recruits aged 20-21 was 22.5, with levels around 23 for older recruits.[30] Because the British population of the late nineteenth century was both stunted and wasted, its mean BMI was somewhat below modern levels but not enough unambiguously to attribute the higher mortality levels of that period to nutritional status. However, the figures shown in table 6 are based on means of the population, and possibly even on groups who were more prosperous than the average; each of the distributions around the means would therefore have contained a significant number of people with levels of BMI below the

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[28] Costa and Steckel 1997:53.

[29] Most of the observations in table 6 refer to age-groups other than 50-64, the basis of the calculations of relative risk from Waaler observations of Norwegian data. That age-group was originally chosen because it showed the most significant relationship between height, weight and mortality, the relationship therefore being weaker for other age-groups. The estimates of relative risk for other age-groups should therefore be taken as rough indicators, rather than precise assessments, of the risk attaching to the heights and weights which are shown.

[30] Costa and Steckel 1997:54 and fig 2.4.

current "danger" level of 20. While it does not seem reasonable to argue, on the basis of the mean values of BMI, that average mortality was greater in the nineteenth century because of the stunting and wasting revealed in these data, it is impossible to be certain without more knowledge of the shape of the distributions.

Since the evidence makes it difficult to make definitive statements about mortality trends, one can do no more than speculate about the components of declines in morbidity, although research on the Union Army veterans may provide relevant evidence. Nor is it possible yet to explore the extent to which the life-time productivity of men and women in the mid-nineteenth century was lowered by their poor nutritional status. However, it is clear that those at the bottom of the height distributions must have been significantly weakened by their earlier history of nutritional status, while those at the bottom of the weight and BMI distributions would have been so wasted as to be lacking in the physical strength required for prolonged manual work.[31] Thus the increased height, weight and BMI shown over time would certainly have made some contribution, which cannot at present be quantified, to the improved productivity of the British labour force during these years.

Comparisons with the United States

It has been known for some time that there was a decline in the mean height of native-born whites in the United States in the middle of the nineteenth century, similar to that found in Britain.[32] The decline appears to have begun at approximately the same time, with the birth cohorts of the 1830s, but to have lasted somewhat longer, the trough occurring in the 1880s rather than in the 1860s. The comparison is made difficult by the fact that there is no national series for US heights from the early 1870s to about 1910,

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[31] It is important at this point to recall that it is likely that the data refer to more privileged social groups and that the extent of stunting and wasting was actually greater than is suggested by these results.

so that for this period the movement of heights has to be interpolated on the basis of data on the Ohio National Guard. However, the decline in the preceding thirty years is well established. The issues are considered again below.

The actual range of heights recorded in the published British data is very similar to that found in the United States, where average male height was about 172 cm in the middle of the nineteenth century, rising to about 177 cm for the birth cohorts of 1960-1979. Mean levels of BMI are also similar, at least in the nineteenth century, but recent US levels of 26 and over have not yet been attained in Britain. Figures 13 and 14 present a direct comparison between the two countries. In commenting on the results for the United States, Costa and Steckel draw particular attention to the fact that differences in BMI between the nineteenth and twentieth centuries are "especially pronounced at older ages", both across the whole population and by occupational class; it is therefore of interest that the same does not appear to be true for Britain.[33] In Britain, the range is greatest for the 26-30 age-group, with a mean BMI (adjusted for the weight of clothing) of 20.7 in the 1800-1819 birth cohort, contrasting with a mean BMI of 24.9 for the same age-group in the 1960-79 cohort. The range at older age-groups is somewhat less; for 51-60 year olds it varies from 23.8 in 1820-1839 to 26.2 in 1920-39 and for 61-70 year olds from 24.6 in 1800-1819 to 26.1 in 1920-39. The explanations given by Costa and Steckel for the observed phenomenon in the United States are, however, tentative and it may be that the difference between the two countries is of little significance.

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[32] Costa and Steckel 1997:50-53.

[33] Costa and Steckel 1997:56. Note that the US data are presented by date of measurement, while the British data are presented in birth cohorts. Adjustment, even if approximate, from one to the other is a matter of simple arithmetic.

Discussion

Relationship to other evidence

How consistent are the published data, analysed in this paper, with other sources of information, in particular the individual military records analysed in *Height, Health and History?* As mentioned above, one of the most significant findings from those records was that there was an apparent decline in the mean height of the British population which began with the birth cohorts of the 1830s and ended with the birth cohorts of the 1860s.[34] This finding is confirmed by the new evidence from group height data and from data on weights and BMI.

The finding that there was a decline in heights in the middle of the nineteenth century attracted particular attention for two reasons. First, it paralleled a similar decline in the United States. Second, the suggestion that there was a fall in nutritional status in Britain in the middle of the nineteenth century appeared to be at variance with information about trends in real wages and incomes. These are generally supposed to have improved from at least the 1840s onwards. Floud *et.al.* suggested that this discrepancy might have been due to the living conditions and disease environment of the growing and industrialising towns of the period, which could have led to declining nutritional status despite rising incomes.

There are essentially three major types of evidence concerned with living standards in the nineteenth century: anthropometric data, mortality data and real wage data. Since the publication of *Height, Health and History* there have been major independent contributions to all three types of evidence, which can now be surveyed for their relevance and comparability to the results reported above.

Anthropometic data

Johnson and Nicholas have recently published the results of the analysis of three entirely different data sets which together confirm that there

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[34] Floud, Wachter and Gregory 1990:

was a decline in mean heights in second and third quarters of the nineteenth century.[35] Their data are taken from the records of about 30,000 female criminals: convicts transported to New South Wales between 1826 and 1840, of prisoners admitted to Newgate Prison in London between 1817 and 1860 and of females listed in a register of "habitual criminals" compiled by Scotland Yard in 1877. They have also analysed data for males transported to Australia and for male habitual criminals.

Johnson and Nicholas first consider how far criminals, male or female, can be considered to be representative of the population and conclude that:

> "While not 'honest men and women', British and Irish criminals are mainly working people who supplemented their incomes by theft. We are confident, therefore, that there are no obvious selection biases that would make the heights of females included in our three data sets unrepresentative of the heights of the working-class female population in Britain and Ireland."[36]

Analysis of these data demonstrates clearly, as is shown in figures 15-17 drawn from their work, that there was a fall in average female heights from the birth cohorts of the 1830s, or possibly slightly earlier, until the birth cohorts of the 1850s, when the records terminate. Johnson and Nicholas summarise their findings:

> "After 1825 working-class women experienced a substantial deterioration in nutritional status, although the fall began earlier and was greater for rural-born than for urban-born women. It is, however, a deterioration that is almost exactly matched by that found in the male criminal data. This decline begins roughly at the same time as that identified in the military recruit data by Floud *et.al.* (1990)."[37]

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[35] Johnson and Nicholas 1997.

[36] Johnson and Nicholas 1997:206-7.

[37] Johnson and Nicholas 1997: 222.

In addition, consideration of the regional distribution of women's heights shows that:

"The general pattern, particularly the disadvantageous position of Londoners, is similar to that found by Floud *et.al.* (1990) for male military recruits. These data support the view that urban disamenities (poor housing and disease environment), together with regional differences in diet and workloads in the industrialising and urbanising regions, reduced the living standards and quality of life for women."[38]

It thus appears that the anthropometric evidence from published data sets, described in this paper, is consistent both with the evidence published in *Height, Health and History* and with that in the entirely distinct but relevant data sets analysed by Johnson and Nicholas.

Mortality data

As was pointed out in *Height, Health and History*, the evidence of changing heights was always consistent with the check to increases in average life expectation which was thought to have occurred from the 1830s onwards. The course of mortality in the nineteenth century, particularly in the towns and cities, has recently been re-examined by Szreter and Mooney.[39] They confirm the importance, first suggested by Woods[40], of examining both the national and individual urban death rates in exploring changes in life expectancy in the nineteenth century. This is because the massive shift of population into the towns and cities so dominated population change that movements from low death rate areas in the countryside to high death rate areas in the towns could significantly affect the average national death rate, without any actual change occurring in either set of places. Woods demonstrated this in theory, while Szreter and Mooney set out to rework census and other materials to explore the issue in practice.

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[38] Johnson and Nicholas 1997: 227-8.

[39] Szreter and Mooney 1998.

[40] Woods 1985

After a painstaking and elegant statistical analysis, Szreter and Mooney conclude that their data demonstrate "a pronounced deterioration in mortality in the second quarter of the nineteenth century."[41] They then proceed to explore the consistency of this result with other evidence, in particular anthropometric data and evidence on the "scale, general patterns and trends of female and juvenile participation in employment and earnings during the period of the industrial revolution" suggesting a decline in the importance of female and child earnings from the 1840s and 1850s onwards.[42] They conclude this exploration by stating that:

> "The present contribution, focusing on the mortality experience of the most highly urban and industrial section of the working population, would therefore support the general implications of both of these other bodies of recent research, in identifying the second quarter of the nineteenth century as a key period of discontinuities and stresses, from the point of view of general patterns in the proletarian 'standard of living'....
>
> "The evidence presented here indicates that, notwithstanding probable rises in male real wage rates, during the second quarter of the nineteenth century there was a serious deterioration in the standard of living of the growing proportion of the population recruited into the urban industrial workforce; and furthermore that this trend of deterioration, although halted in the late 1850s and 1860s, was not significantly reversed until as late as the 1870s and 1880s."[43]

These results go far to explain the decline in heights in the middle of the nineteenth century and the gradual increase in heights after the 1860s. However, a further paradox has been created by the evidence on weights and

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[41] Szreter and Mooney 1998: 101.

[42] Szreter and Mooney 1998: 109.

[43] Szreter and Mooney 1998: 109-110

BMI presented above, which suggests that there was little if any increase in average male or female weight and BMI until the birth cohorts born early in the twentieth century. The paradox is that there appears to have been no improvement in weight and BMI at a time at which, it is generally held, real wages were rising, mortality was falling and there had been substantial progress in combating the major infectious diseases which had afflicted the British population.

The paradox might be resolved by suggesting that the benefits of these changes were reflected sequentially in the bodies of British men and women, so that the initial impact was felt on heights while only later, perhaps after some threshold level of heights had been reached and environmental improvements continued, was there an increase in weight. In order to explore these possibilities further, it would be desirable to secure evidence about other countries passing through the same processes, to examine whether the same pattern occurred there.

Real Wage data

If, with a proviso about weight and BMI, it is now accepted that there is consistency between data on nutritional status and on mortality, the clear need is for re-examination of the data on movements in real wages. This is particularly so since it was the discrepancy between data on heights and estimates of real wages that caused many commentators to question the utility or validity of height measurements in general as well as with reference to Britain in the nineteenth century.

Fortunately, this re-examination has recently taken place, with the reworking by Charles Feinstein of his estimates of real income in Britain in the mid-nineteenth century. He concludes that there was a “very limited and slow improvement in average real earnings for almost the whole of the first half of the nineteenth century, with more significant gains achieved only after that date.” Moreover, the benefit of these gains was reduced by increases in the number of dependants per worker and in unemployment. As a result:

> "The present account of trends in living standards is in accord with the evidence on mortality. It also eliminates the conflict with the height data for the early nineteenth century..... There is no longer the paradox of a decline in nutritional status occurring at a time of an apparently swift advance in living standards."[44]

If Feinstein's conclusion is accepted, then the much discussed discrepancy between measures of height and measures of real wages has been resolved, at least in Britain. It remains true, of course, that movements in height, weight and BMI reflect much more than movements in real wages, just as real wages are themselves inadequate measures of welfare. What Gregson and Grubb have described as the NECDEC, the **n**utrition-**e**xertion-**c**limate-**d**isease **e**nvironments of **c**hildren, continue together to determine growth in childhood and to affect the changing weight and BMI of adults.

Causation and conclusion

The demonstration that anthropometric, mortality and real wage data now agree in their description of trends in British living standards in the middle of the nineteenth century does not, of course, explain those trends. Both in Britain in the United States, which appears to have experienced similar patterns, discussion has focused on changes in the disease and work environments, which might have had a deleterious effect on nutritional status despite improvements in income.[45] In the United States, explanations based on the spread of disease within the growing cities are given additional credence by the fall in average life expectancy which occurred between 1870 and 1880, after two decades of improvement. Explanations based on the spread of disease are even more plausible in the United States than in Britain, since there is much less evidence in the former country of occupational or socio-economic differences in height, so much so that Costa

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[44] Feinstein 1997.

[45] The various explanations are surveyed in Costa and Steckel 1997:63-70.

> and Steckel refer to "the seemingly weak association in the United States between individual heights and access to resources."[46]

However, it has to be remembered that, as a matter of historiography in both countries, what Gregson and Grubb describe as the NECDEC explanation, concentrating on the disease environment, was put forward precisely because it was thought that the height evidence conflicted with the real wage evidence. Paradoxically, the recent evidence that there is no such conflict drives the search for explanation even further back historiographically, to the question of why the working classes did not benefit for so long from the great changes to economy and society which we call the industrial revolution.

This discussion of the implications of the new data on height, weight and body mass has focused on the events of the middle of the nineteenth century because of the centrality of that period to debates on British living standards. But it should not be forgotten that the new evidence of weight and body mass suggests that the nutritional status of British adults and children continued to be poor well into the twentieth century. Even if heights rose towards the end of the nineteenth century - and the data reported here throw some doubt on that earlier conclusion - weight and body mass certainly lagged behind.

It is at first sight puzzling that significant increase in mean weight, for both males and females, should have followed increases in mean height and that the increase, when it came in the twentieth century, should have been so rapid and substantial.[47] Logically, one would assume that a period of

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[46] Costa and Steckel 1997:64.

[47] One possible explanation is that the movements in mean weight are an artefact of the method used to adjust for the weight of clothing. This seems unlikely, however, for two reasons. First, the adjustments were made to observations for male adults in the birth cohorts of 1800-1819 to 1840-1859, and for 19-25 year olds only in 1860-1879. They thus do not affect the weights shown from 1885 onwards. Second, the observations for the earlier period, without adjustment for weight of clothing, would have been implausibly large, as would have been the gap between them and later observations. It is possible, of course, that the socio-

economic growth would give rise to increases in mean weight;
men and women born in a period of relatively low mean incomes, and with the heights associated with those incomes, cannot change their heights as incomes rise, but might well increase in weight, at least until late middle age[48] This is indeed what occurred within individual birth cohorts; the older they became, the heavier.

However, the logic which applies within a birth cohort does not apply between birth cohorts. The data reported here suggests that, as populations move from a state of relative deprivation and under-nutrition, the mean height - presumably of infants and children - increases first, with mean weight and body mass increases lagging behind. Only further investigation, in other countries, will reveal whether this is plausible.

The findings reported in this paper constitute only the beginning of a full exploration of separate and complementary changes in British height, weight and body mass. Much remains uncertain, in the main because of the uncertainties surrounding some of the published data sets. Despite these difficulties, it remains important for scholars to continue to investigate the complex mixture of environmental influences on the human body and their implications for our understanding of trends in mortality, morbidity and productivity.

This is particularly so since it is clear both that significant changes are still occurring and that we have not yet experienced, let alone understood, some of the consequences of changes that occurred in the recent past. As the tables clearly show, there has been in recent decades a continuing increase in height, weight and body mass, all presumably associated with improvements in nutritional status. If, as is suggested by evidence from many countries, but particularly from Norway and the United States, these improvements in childhood and early adulthood nutritional status show

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economic composition of the samples shifted upwards, so that both heights and weights appeared to increase, but examination of the various data sets does not support this view.

[48] It has indeed been argued that increased income levels, by increasing weight relative to a fixed base of height, have contributed to rising levels of heart disease.

themselves in long-term improvements in morbidity and productivity and in long-term declines in mortality, then it is clear that there is much improvement in the human condition still to come, as the birth cohorts of recent years - immensely privileged as they are in historical terms - continue to mature.[49] While obesity is a source of some concern in the United States and other countries, it is likely at least for many years to be of less significance than the overall increase in human nutritional status which is clearly shown in this paper.

[49] Fogel 1997; Harris 1997.

List of Tables and Figures

Table 1. The effect of different allowances for the weight of clothes.

Male weight (kg) including clothes	Weight less Quetelet allowance of 1/18	Weight less Roberts allowance of 10 lb. (4.54 kg)
40	37.78	35.46
50	47.22	45.46
60	56.67	55.46
70	66.11	65.46
80	75.56	75.46

Female weight (kg) including clothes	Weight less Quetelet allowance of 1/24	Weight less Roberts allowance of 10 lb. (4.54 kg)	Weight less Kemsley allowance of 6 lb. (2.72 kg)
40	38.33	35.46	37.28
50	47.92	45.46	47.28
60	57.50	55.46	57.28
70	67.08	65.46	67.28
80	76.67	75.46	77.28

Table 2.

The number of observations in published sources by birth cohort, gender and age of those measured. Each observation is of a group of individuals with the specified characteristics of date of birth, age and gender. Children are aged 18 and younger, adults 19 and older.

Birth Cohort	Male Adults	Male Children	Female Adults	Female Children
1810s	17			
1820s	4	4		4
1830s	4			
1840s	5	10		
1850s	24	9	3	
1860s	27	62	10	40
1870s	17	54	2	53
1880s	21	5		5
1890s	19	63	2	54
1900s	28	38	15	37
1910s	26	36	7	25
1920s	13	29	8	24
1930s	7	47	6	39
1940s	8	44	8	40
1950s	6	34	6	34
1960s	4	15	4	15
1970s		10		10

Table 3.

Mean heights of adult males, from published sources, Britain 1820-1979.

Birth cohort	Age 19-25	Age 26-30	Age 31-35	Age 36-40	Age 41-50	Age 51-60	Age 61-70	Age >70	**Mean of Means**
1800-1819		1.68					1.74		**1.71**
1820-1839					1.73	1.73			**1.73**
1840-1859	1.71	1.71	1.72	1.73					**1.72**
1860-1879	1.71				1.75	1.74	1.67		**1.72**
1880-1899	1.73	1.75	1.74	1.74	1.74				**1.74**
1900-1919	1.73	1.70					1.71	1.68	**1.71**
1920-1939	1.75				1.74	1.73	1.71		**1.73**
1940-1959	1.76	1.75	1.75	1.75	1,74				**1.75**
1960-1979	1.76	1.76							**1.76**

Note: *Height, Health and History*, table 4.1, can be used to calculate mean heights for the 24-29 age group by birth cohort as follows:

1800-1819	1.71 m
1820-1839	1.70 m
1840-1859	1.69 m
1860-1879	1.70 m

Table 4

Mean weight of adult males, from published sources, Britain 1800-1979. (Weights adjusted for the weight of clothing are shown in brackets.)

Birth cohort	Age 19-25	Age 26-30	Age 31-35	Age 36-40	Age 41-50	Age 51-60	Age 61-70	Age >70
1800-1819		61.94 (58.50)					78.51 (74.15)	
1820-1839					74.25 (70.13)	75.34 (71.16)		
1840-1859	66.37 (63.31)	69.06 (65.22)	72.50 (68.47)	74.52 (70.38)				
1860-1879	65.07 (61.93)				73.67	75.16	62.19	
1880-1899	66.00	68.48	69.28	70.42	71.19			
1900-1919	63.45	61.02					74.85	70.85
1920-1939	66.08				77.53	77.5	76.28	
1940-1959	71.40	73.80	76.70	78.65	78.84			
1960-1979	71.40	77.35						

Table 5

Mean BMI of adult males, from published sources, Britain 1800-1979. (BMI values based on weights adjusted for the weight of clothing are shown in brackets).

Birth cohort	Age 19-25	Age 26-30	Age 31-35	Age 36-40	Age 41-50	Age 51-60	Age 61-70	Age >70
1800-1819		21.91 (20.70)					24.58 (24.64)	
1820-1839					23.38 (23.52)	23.76 (23.88)		
1840-1859	21.31 (21.51)	21.94 (22.18)	22.84 (23.01)	23.38 (23.51)				
1860-1879	21.03 (21.06)				24.02	24.42	22.38	
1880-1899	22.03	22.32	22.71	23.12	23.46			
1900-1919	21.07	21.03					25.60	25.05
1920-1939	21.54				25.63	26.21	26.09	
1940-1959	23.00	24.00	24.98	25.90	26.10			
1960-1979	23.04	24.93						

Table 6.

Relative risk of mortality, adult males, Britain 1800-1979.

This table compares the height, weight and BMI of adult males in Britain with tables of relative mortality risk for Norwegian males aged 50-64, first by weight (kg) and height (m) and second by BMI and height (m), taken from Fogel 1993: tables A1 and A2, pp. 36-38.

Age	Birth Cohort	Mean Height	Mean Weight	Mean BMI	Relative risk for height and weight	Relative risk for height and BMI
18-25	1840-59	1.71	63.3	21.5	1.09	1.05
	1860-79	1.71	61.9	21.1	1.13	1.15
	1880-99	1.73	66.0	22.0	0.99	1.00
	1900-19	1.73	63.4	21.1	1.09	1.09
	1920-39	1.75	66.1	21.5	0.98	0.95
	1940-59	1.76	71.4	23.0	0.86	0.86
	1960-79	1.76	71.4	23.0	0.86	0.86
26-30	1800-19	1.68	58.5	20.7	1.24	1.23
	1840-59	1.71	65.2	22.2	1.03	1.05
	1880-99	1.75	68.5	22.3	0.91	0.95
	1900-19	1.70	61.0	21.0	1.16	1.18
	1940-59	1.75	73.8	24	0.84	0.84
	1960-79	1.76	77.4	24.9	0.81	0.81
31-35	1840-59	1.72	68.5	23.0	0.94	0.96
	1880-99	1.74	69.28	22.7	0.92	0.91
	1940-59	1.75	76.7	25.0	0.83	0.83

Age	Birth Cohort	Mean Height	Mean Weight	Mean BMI	Relative risk for height and weight	Relative risk for height and BMI
36-40	1840-59	1.73	70.4	23.5	0.91	0.89
	1880-99	1.74	70.4	23.1	0.90	0.91
	1940-59	1.75	78.65	25.9	0.84	0.84
41-50	1820-39	1.73	70.2	23.5	0.91	0.89
	1860-79	1.75	73.7	24.0	0.84	0.84
	1880-99	1.74	71.2	23.5	0.89	0.87
	1920-39	1.74	77.5	25.6	0.85	0.86
	1940-59	1.74	78.8	26.1	0.86	0.86
51-60	1820-39	1.73	71.2	23.9	0.9	0.89
	1860-79	1.74	75.2	24.4	0.85	0.87
	1920-39	1.73	77.5	26.2	0.88	0.88
61-70	1800-19	1.74	74.1	24.6	0.86	0.85
	1860-79	1.67	62.2	22.3	1.14	1.16
	1900-19	1.71	74.9	25.6	0.92	0.92
	1920-39	1.71	76.3	26.1	0.92	0.92
>70	1900-19	1.68	70.85	25.1	0.99	0.99

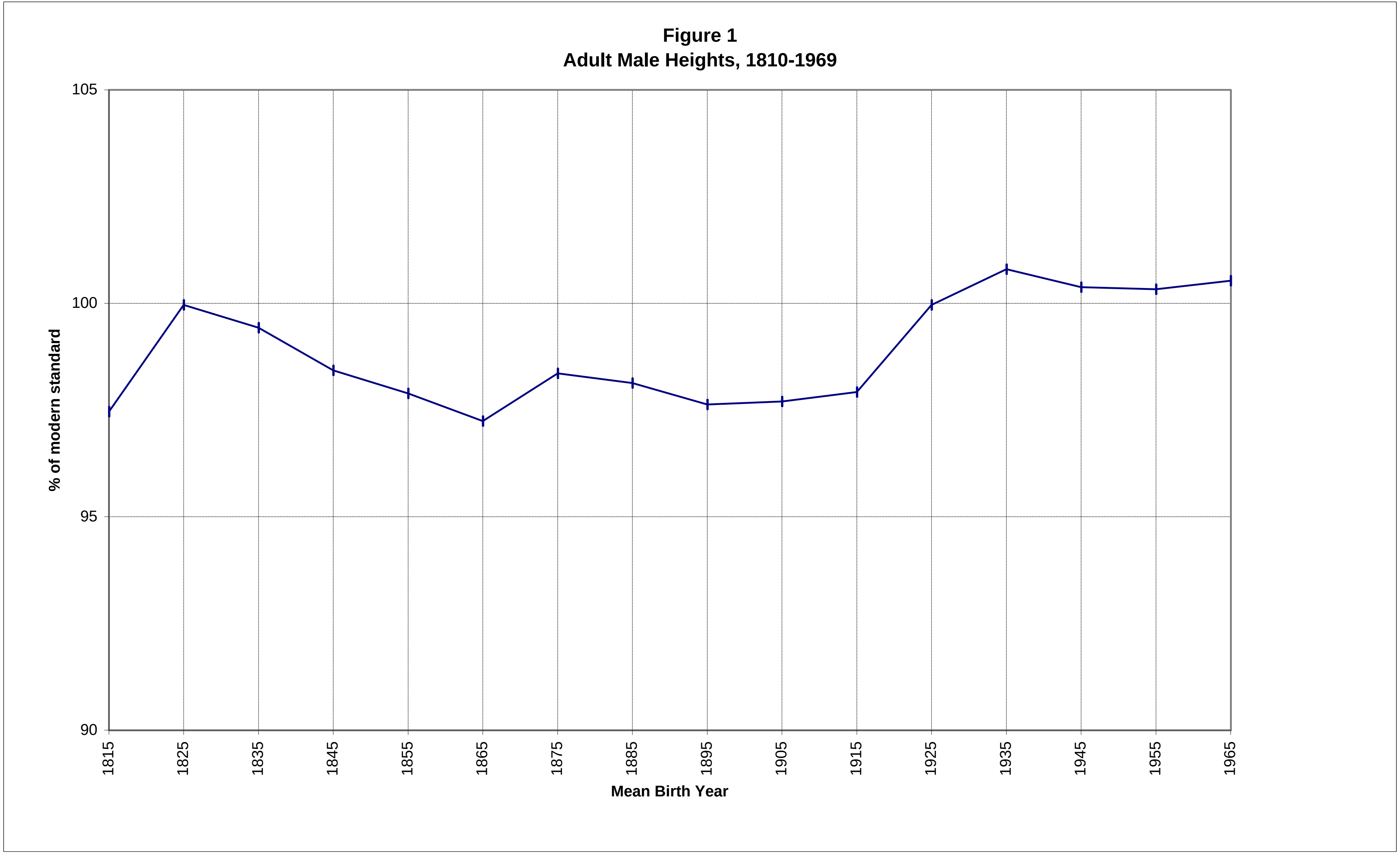
Figure 1
Adult Male Heights, 1810-1969
105
100
95
90
% of modern standard
1815
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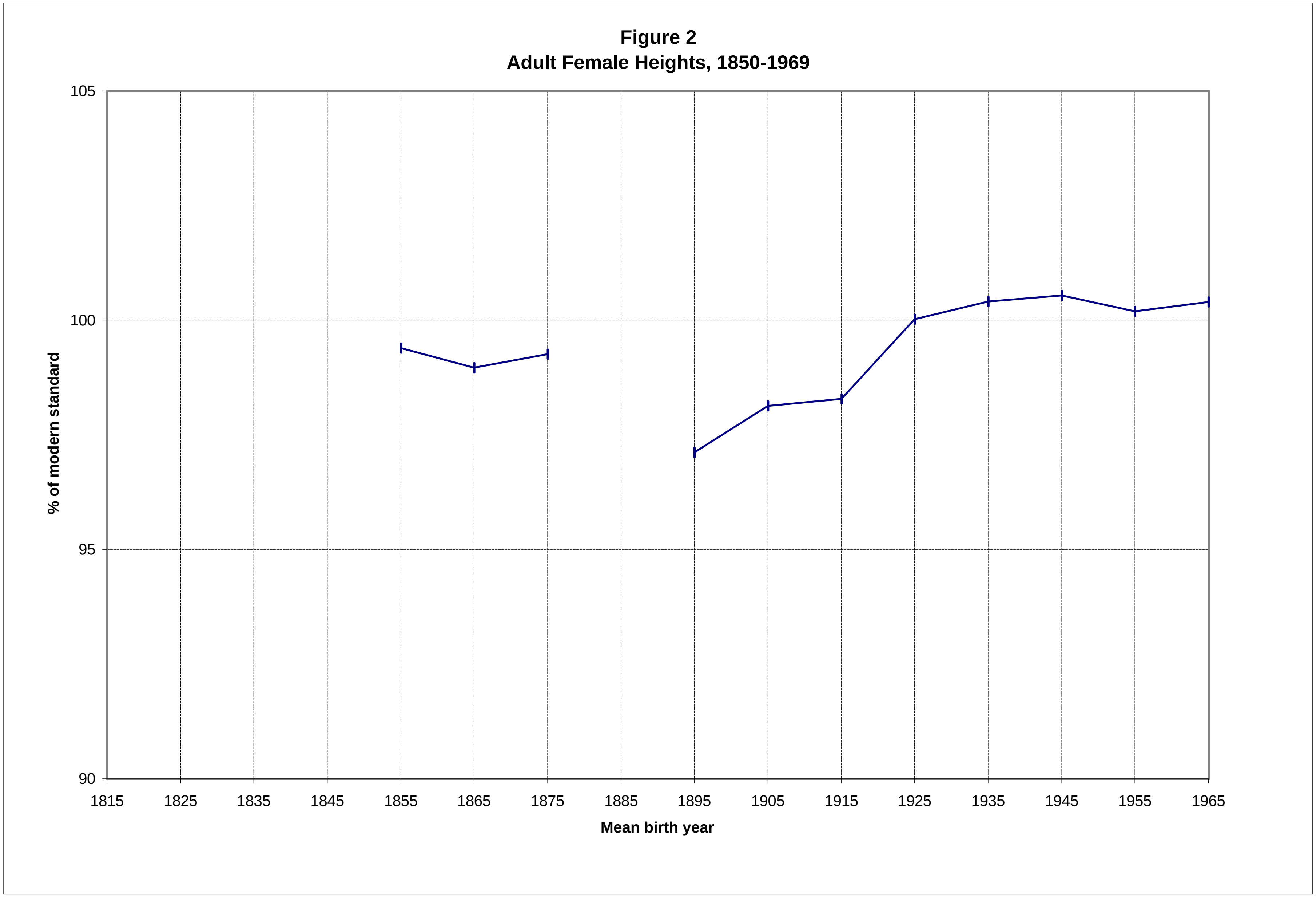
Mean Birth Year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Adult Female Heights, 1850-1969
105
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% of modern standard
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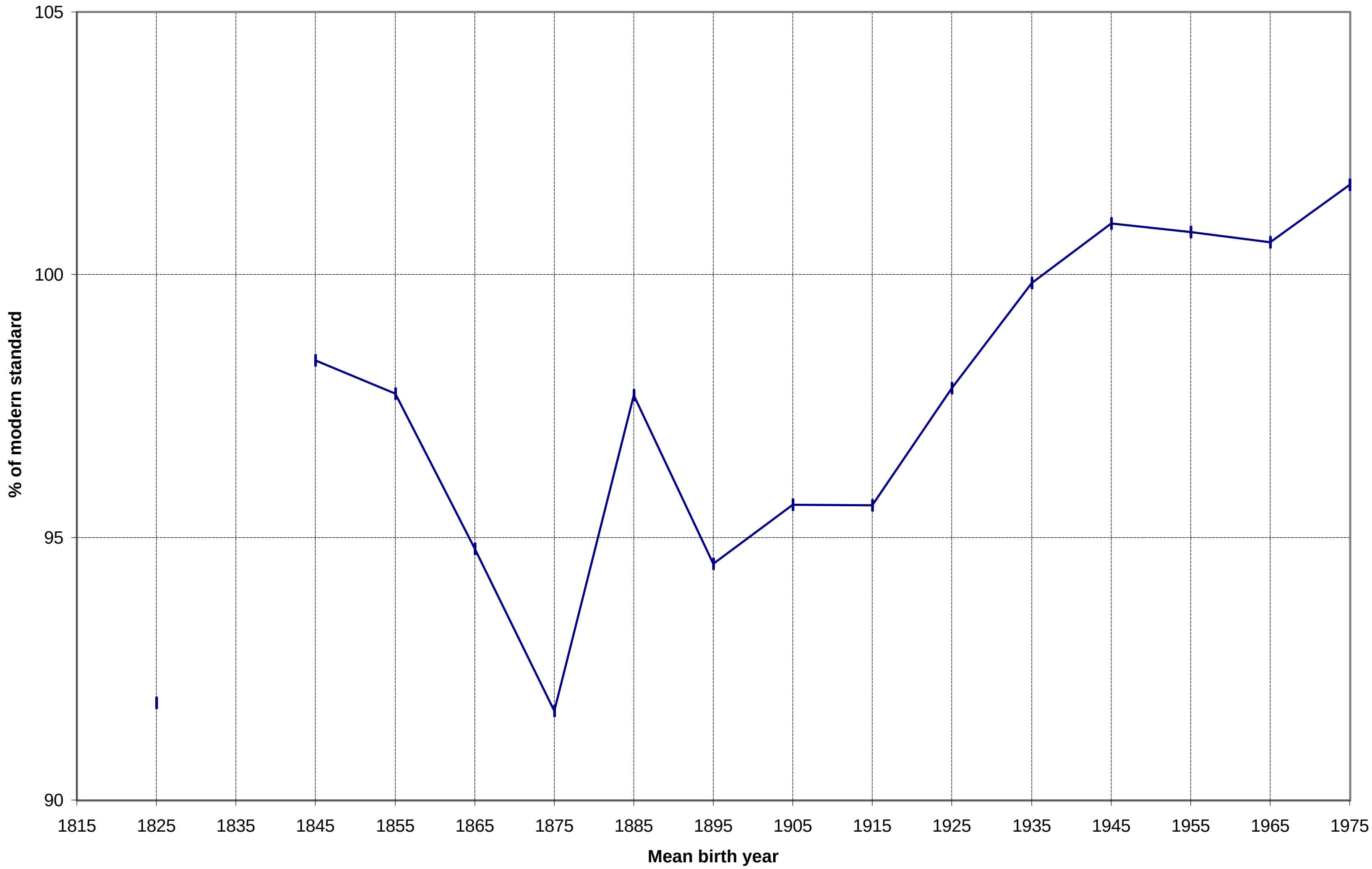
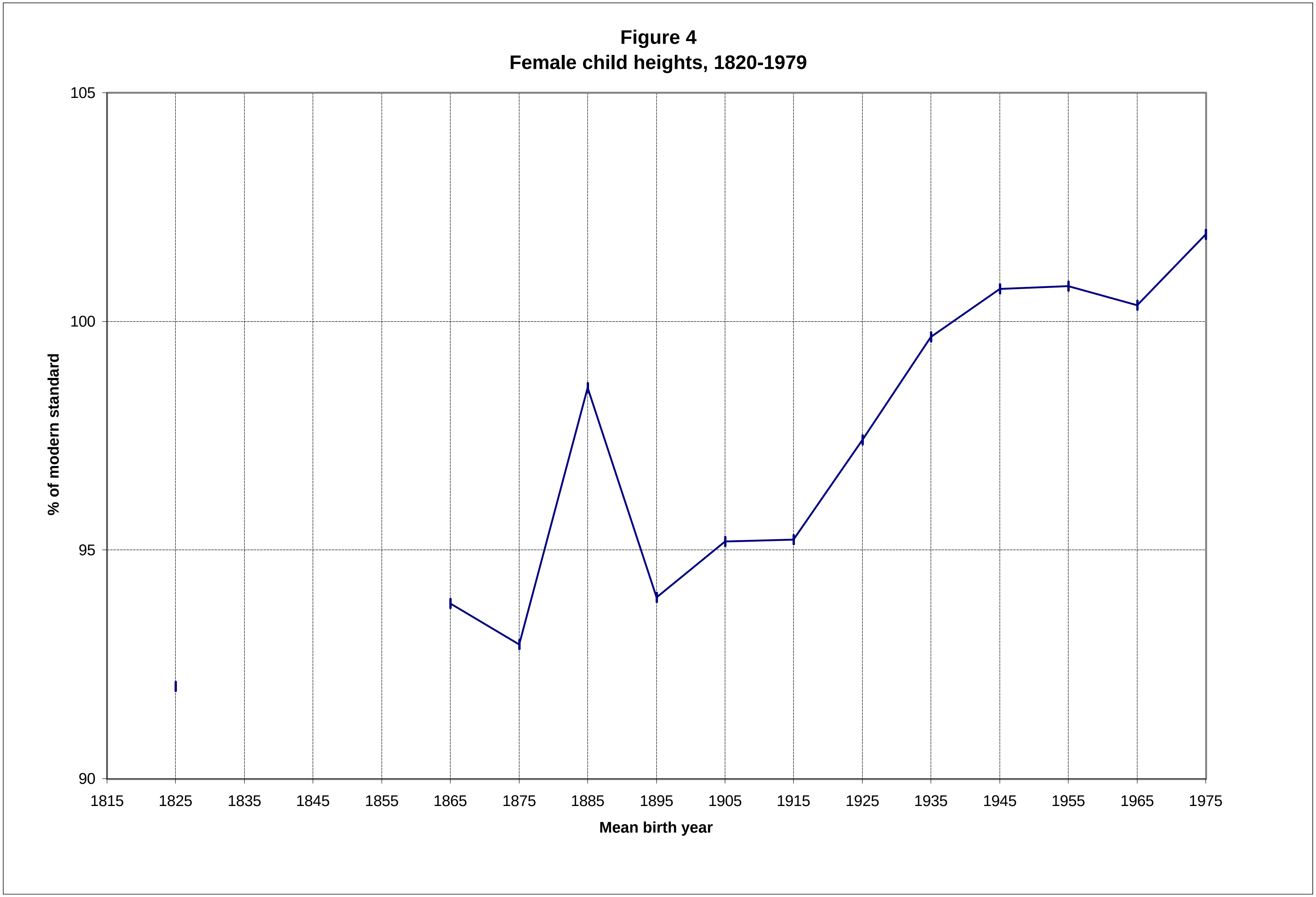
1965
Mean birth year

Figure 3
Male Child Heights, 1820-1979

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Female child heights, 1820-1979
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% of modern standard
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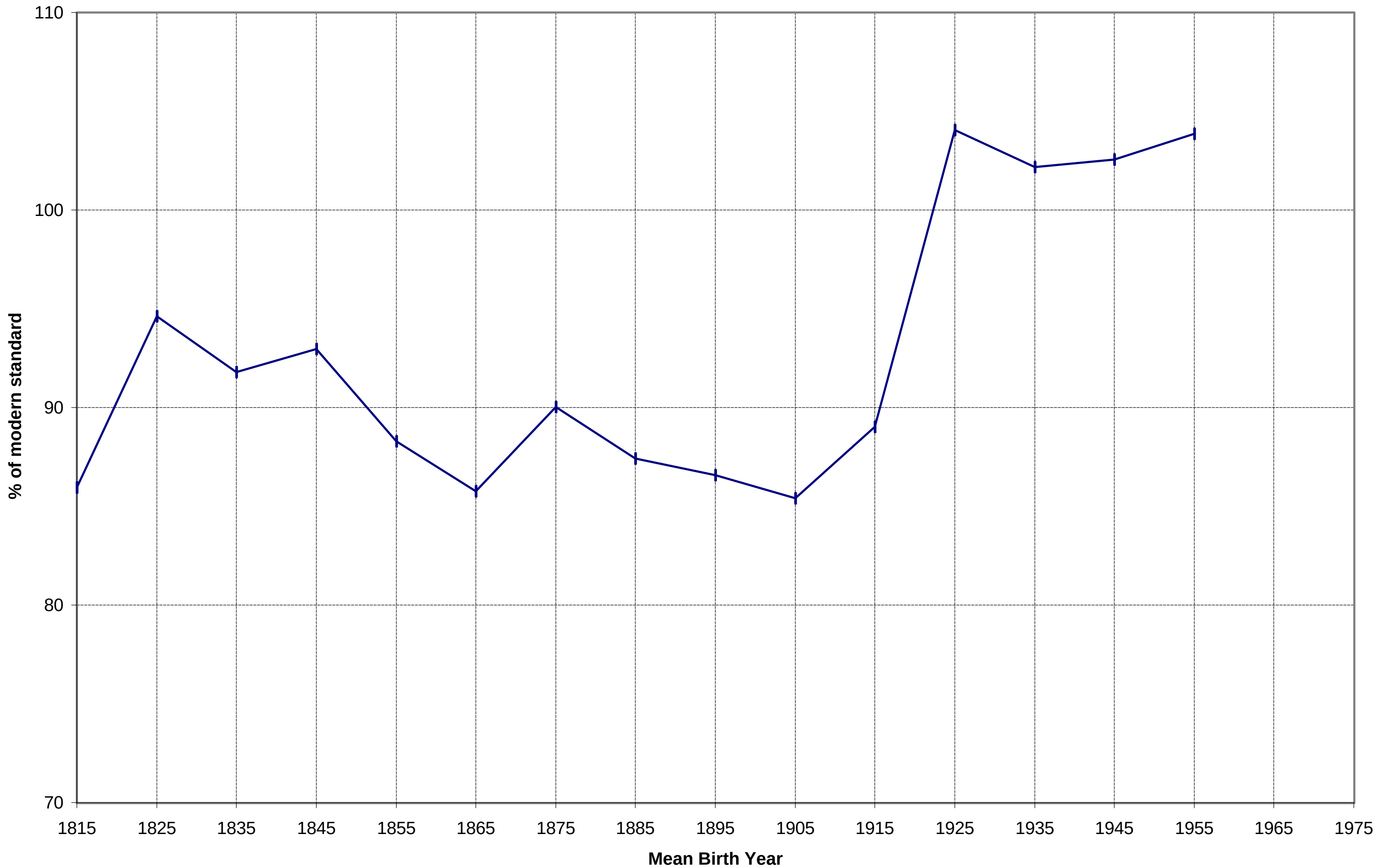
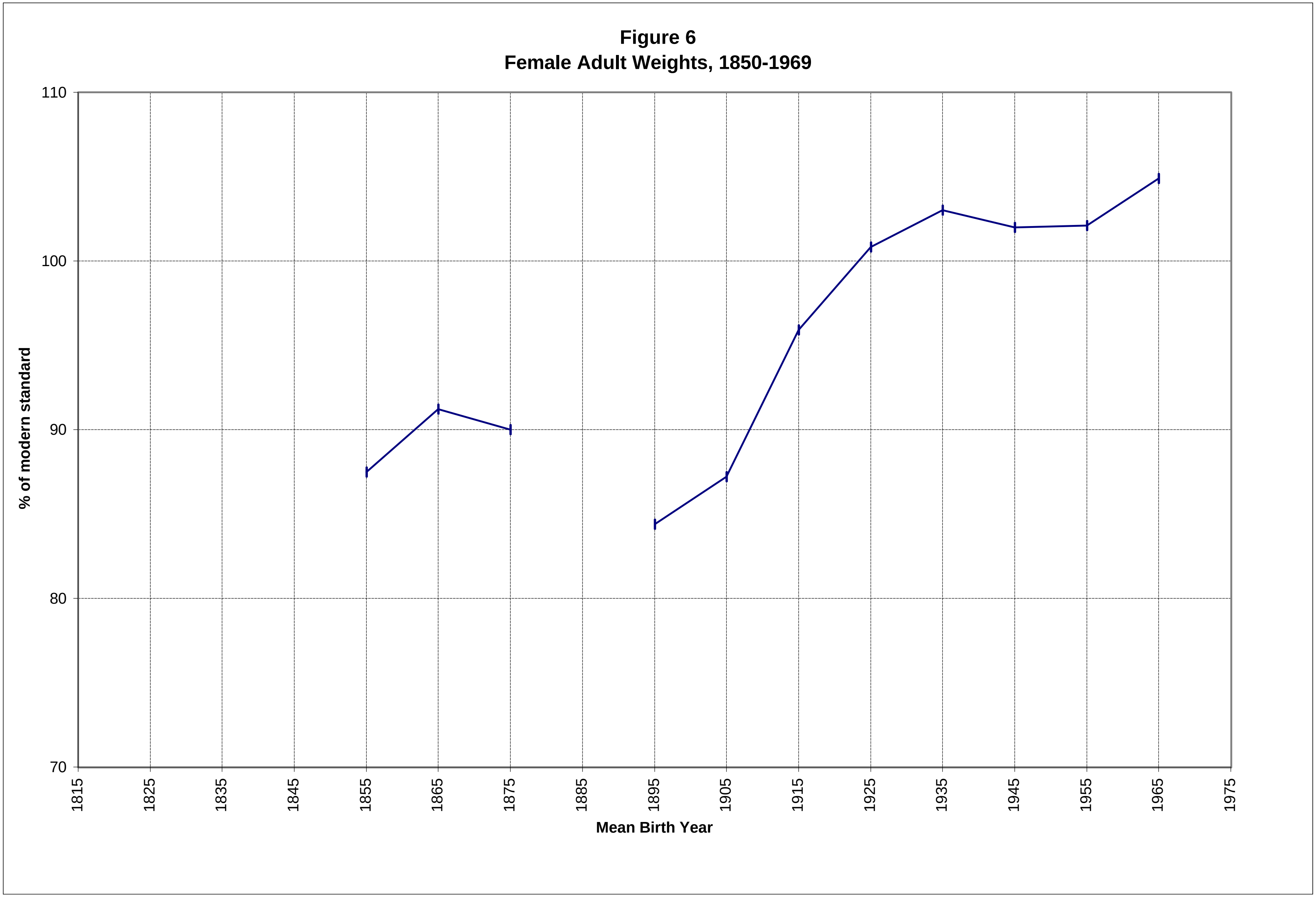
1975
Mean birth year

Figure 5
Adult Male Weights, 1810-1969

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Female Adult Weights, 1850-1969
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% of modern standard
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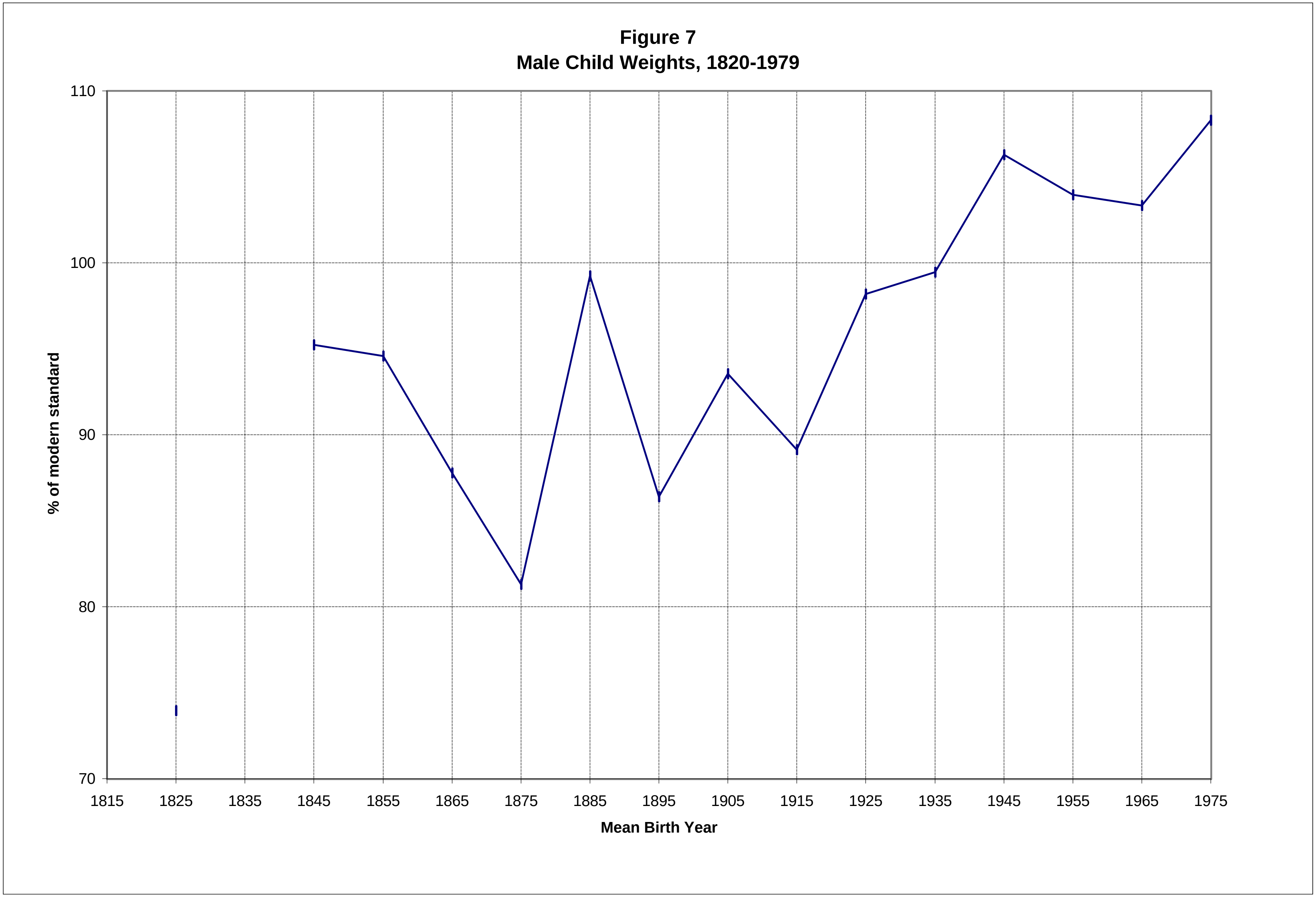
Mean Birth Year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Male Child Weights, 1820-1979
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% of modern standard
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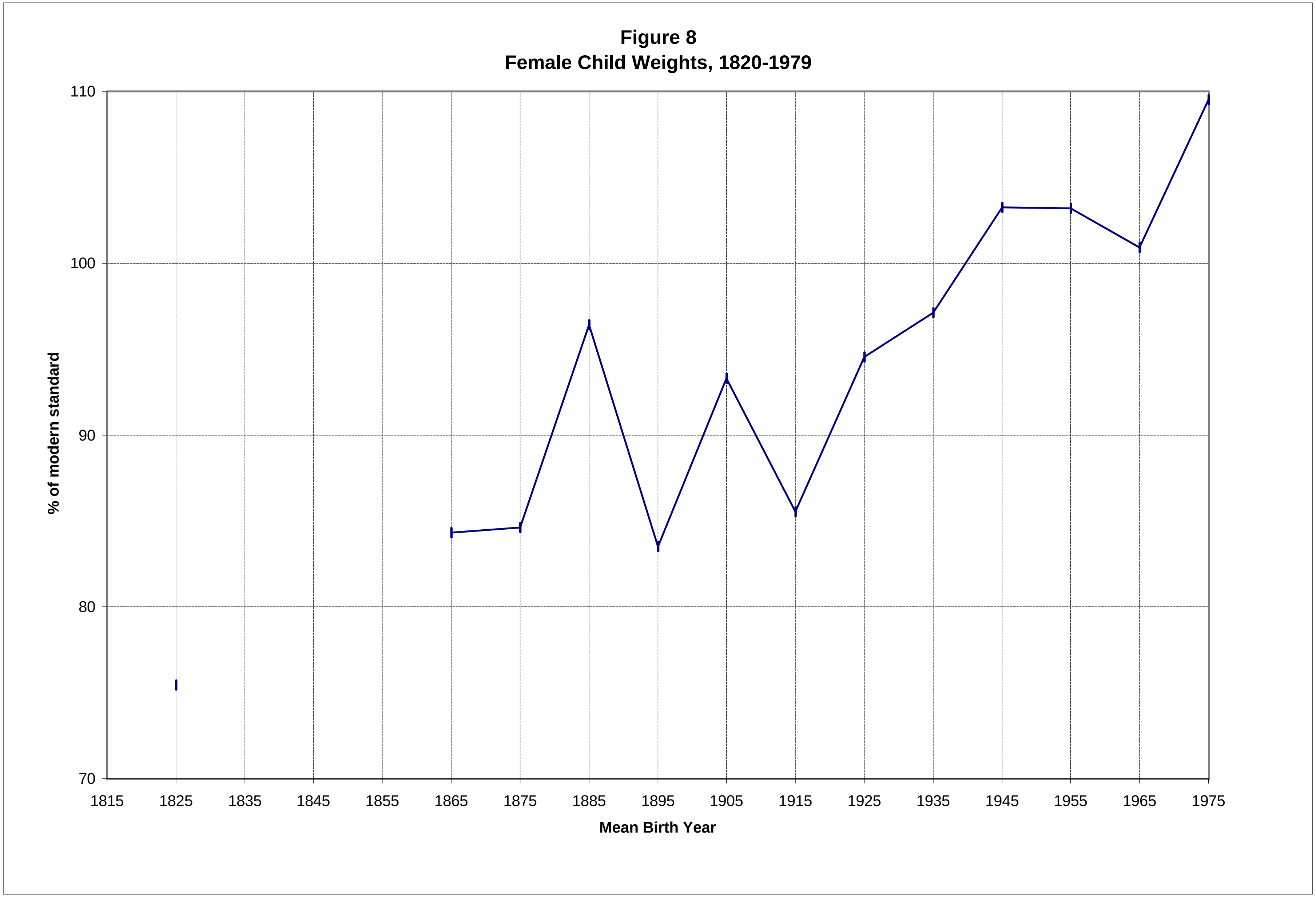
Mean Birth Year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Female Child Weights, 1820-1979
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% of modern standard
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1965
1975
Mean Birth Year

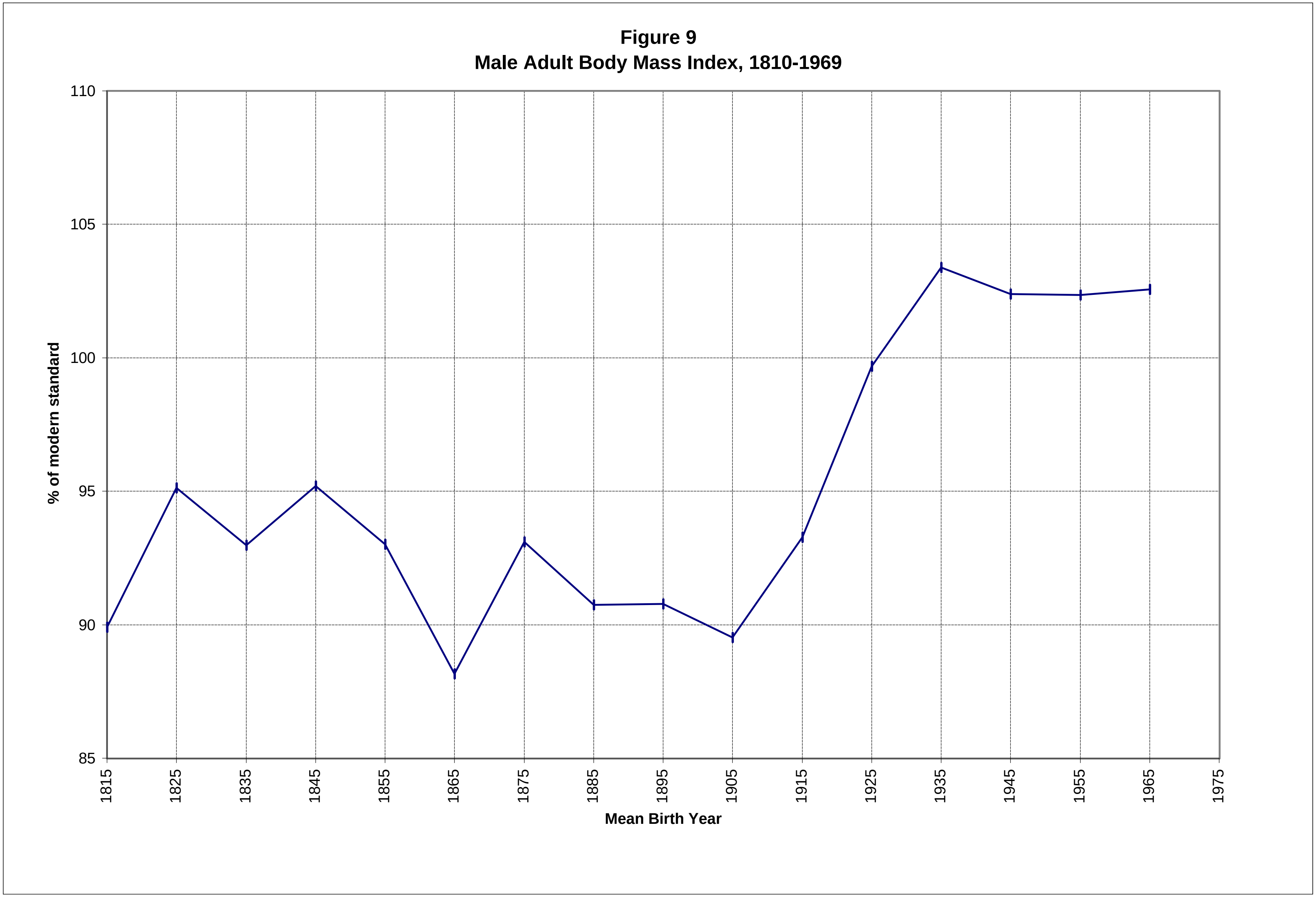
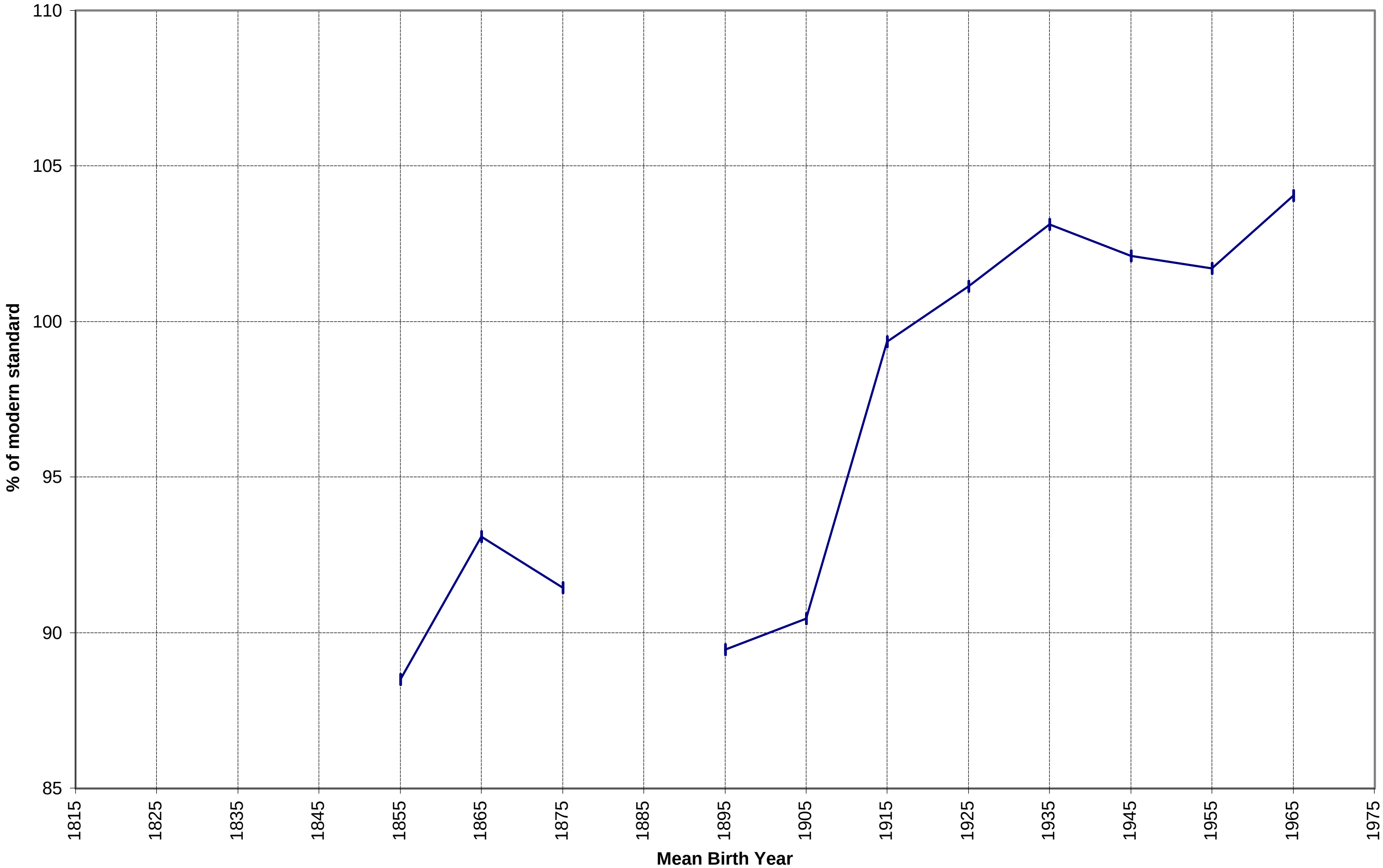


Figure 9
Male Adult Body Mass Index, 1810-1969
% of modern standard
110
105
100
95
90
85
1815
1825
1835
1845
1855
1865
1875
1885
1895
1905
1915
1925
1935
1945
1955
1965
1975
Mean Birth Year

Figure 10
Female Adult Body Mass Index, 1850-1969



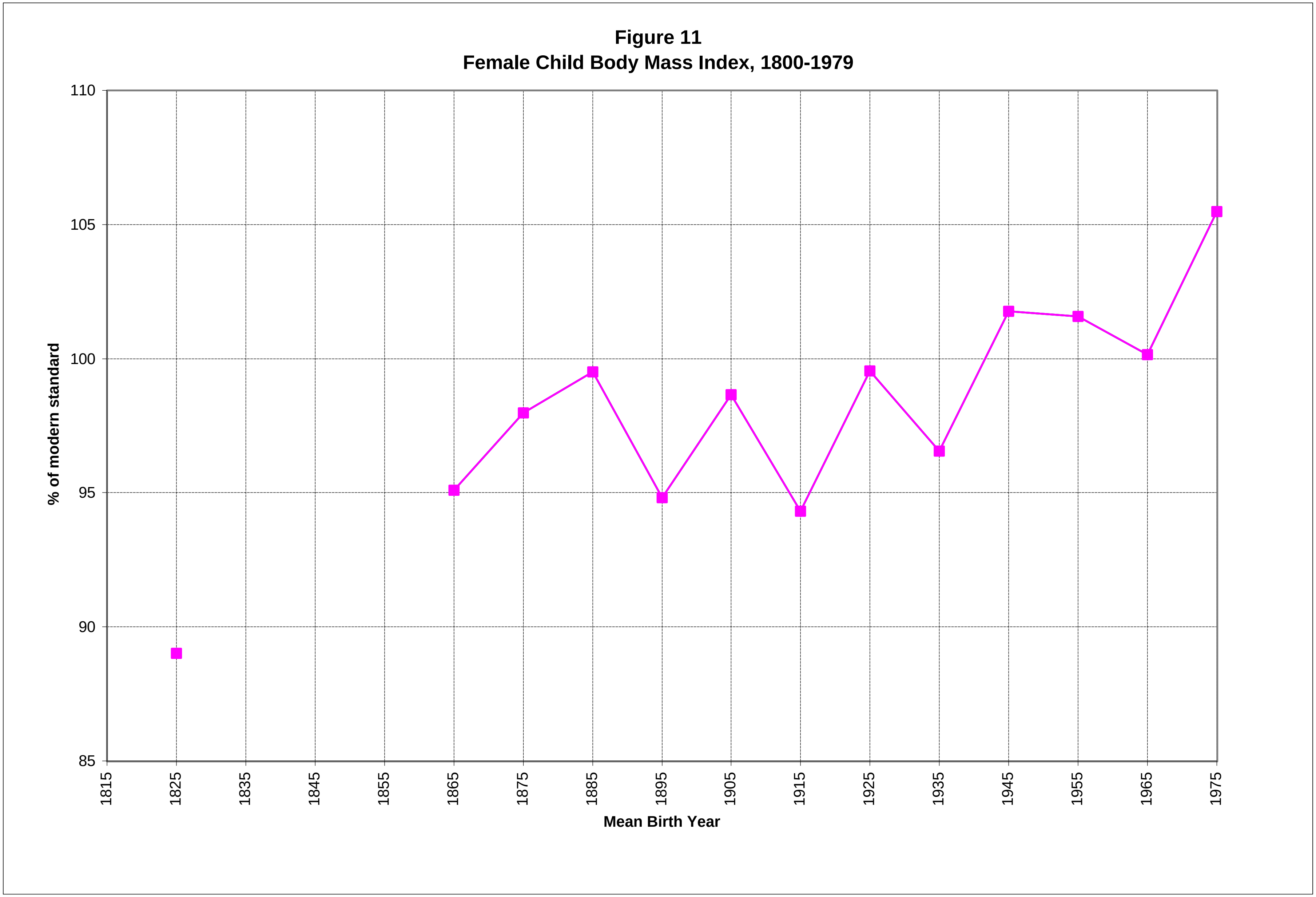


Figure 11
Female Child Body Mass Index, 1800-1979
% of modern standard
110
105
100
95
90
85
1815
1825
1835
1845
1855
1865
1875
1885
1895
1905
1915
1925
1935
1945
1955
1965
1975
Mean Birth Year

Figure 12
Female Child Body Mass Index, 1800-1979

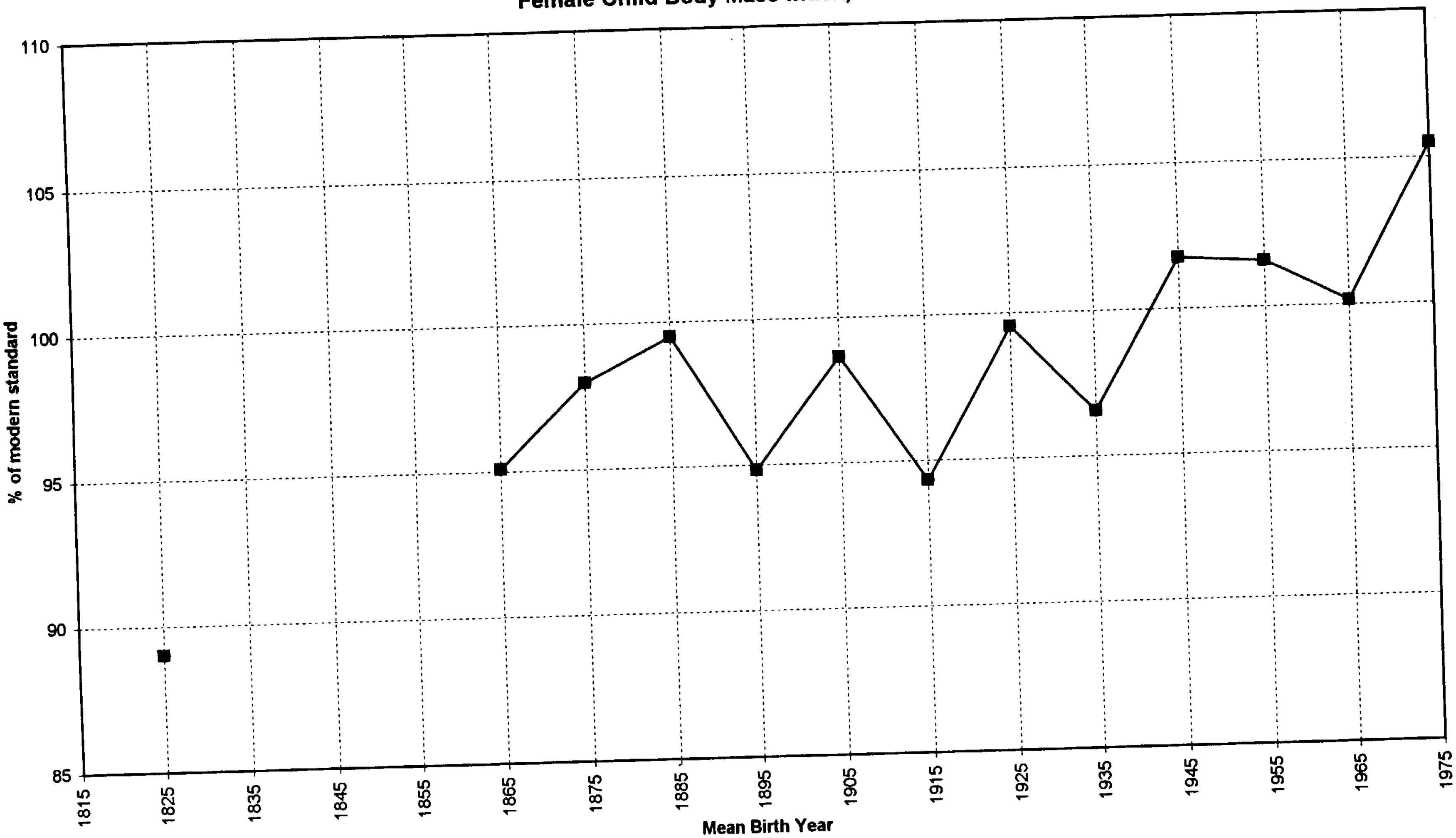


FIGURE 13

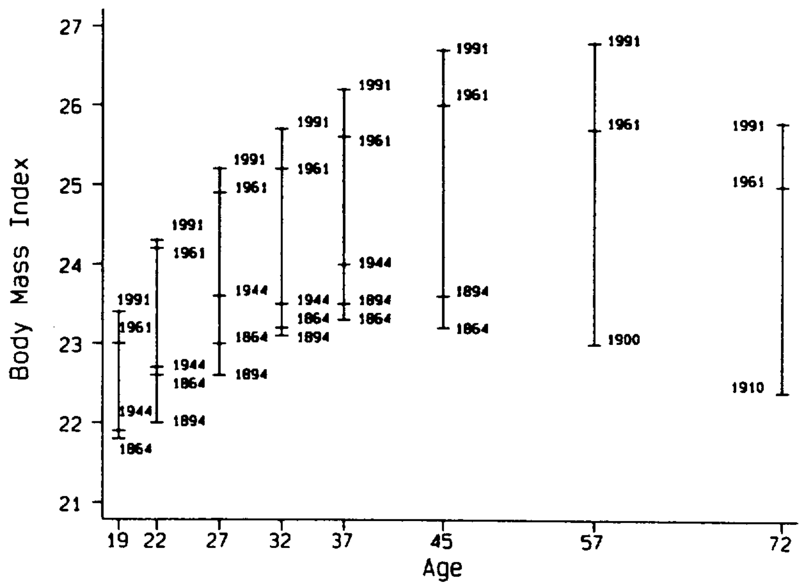


Fig. 2.4 Mean BMI by age group and year, 1863–1991

Note: The age groups are centered at the marks and are ages 18–19, 20–24, 25–29, 30–34, 35–39, 40–49, 50–64, and 65–79. For some years BMI is not available for a specific age group. Calculated from Anthropometric Statistics of Union Army Recruits, Early Indicators of Later Work Levels, Disease, and Death, Hathaway and Foard (1960), Karpinos (1958), 1959–62 NHES, and 1991 NHIS. See the appendix for a description of these data sets.

Source : Steckel and Costa 1997:55

Figure 14: Mean male BMI by age-group and year, Britain 1800-1979
(Source: Table 5)

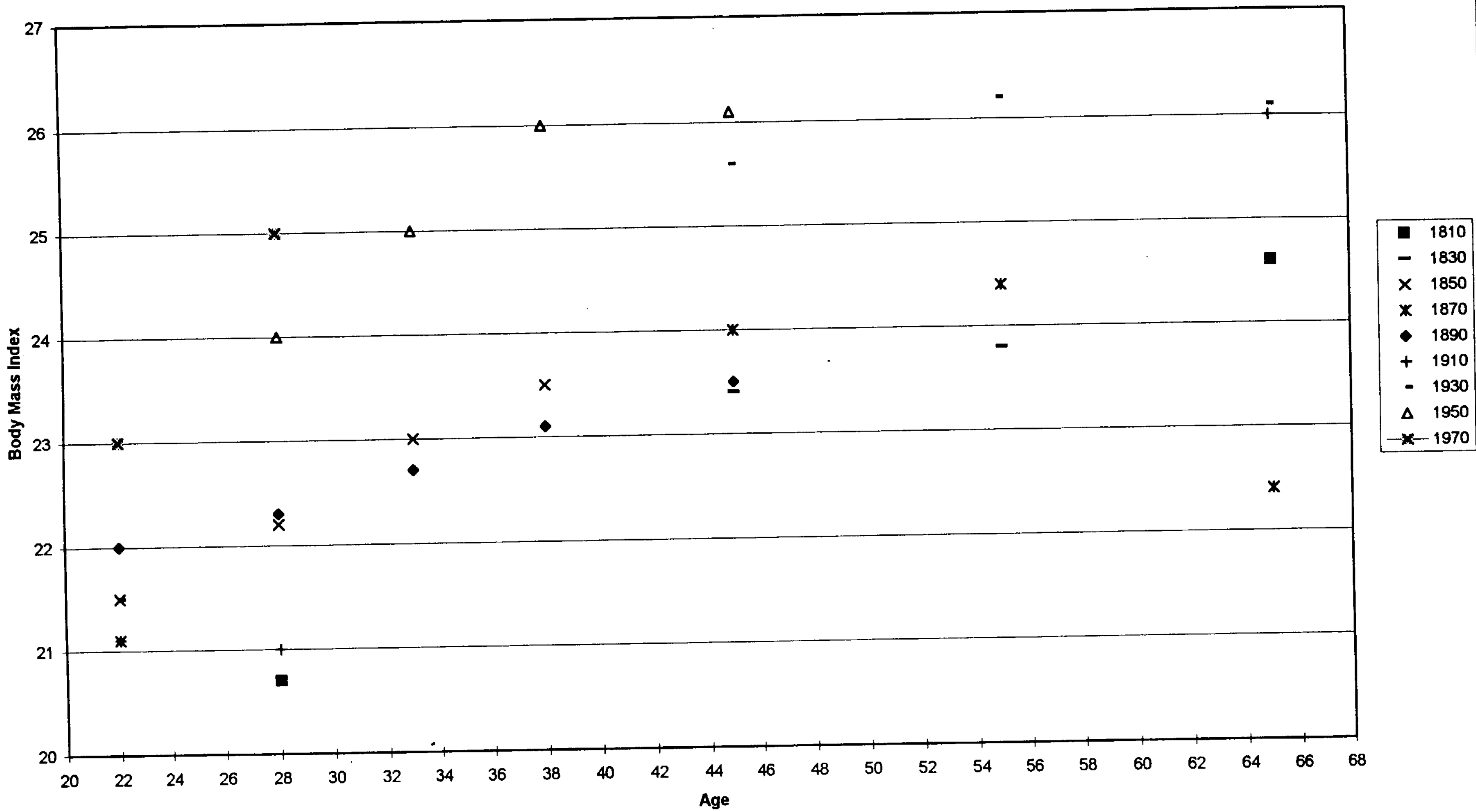


FIGURE 15

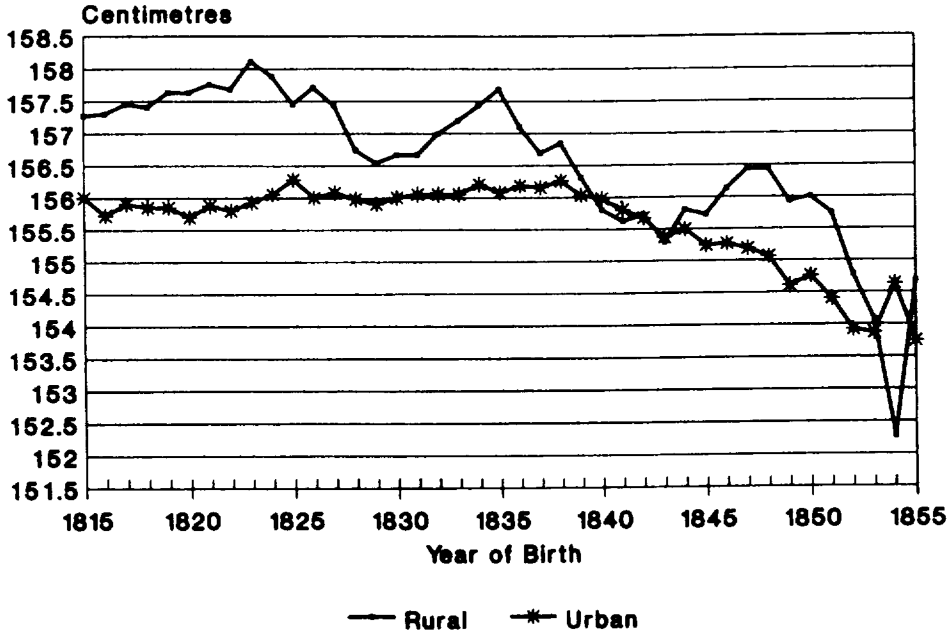


Fig. 6.9 Urban and rural female heights, 1815–55, ages 23–49
Sources: Newgate Prison Registers and *Alphabetical Register of Habitual Criminals.*

(Source: Johnson and Nicholas 1997:221)

FIGURE 16

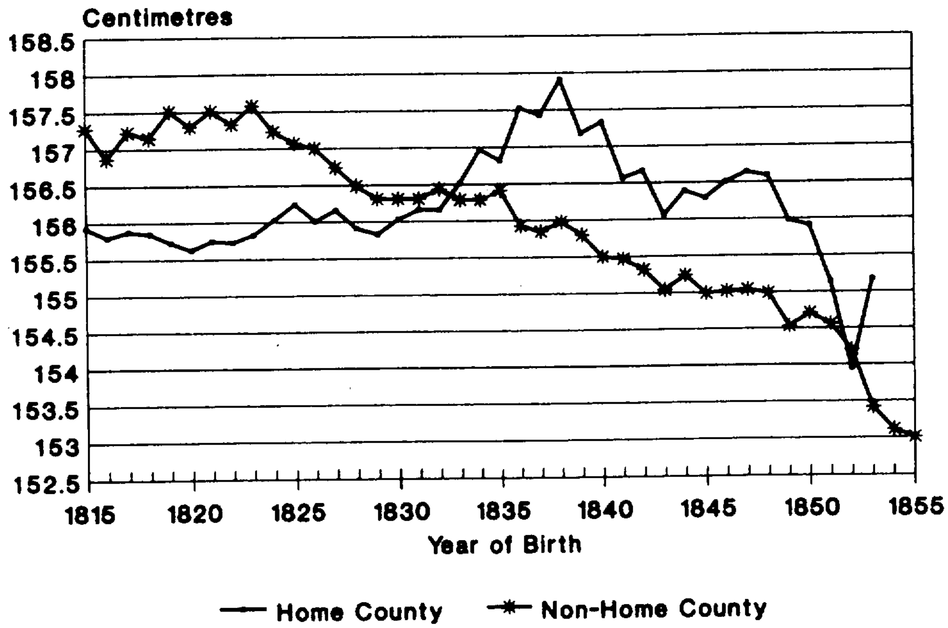


Fig. 6.10 Female heights, Home and non-Home County, ages 23–49
Sources: Newgate Prison Registers and *Alphabetical Register of Habitual Criminals.*

(Source : Johnson and Nicholas 1997:221)

FIGURE 17

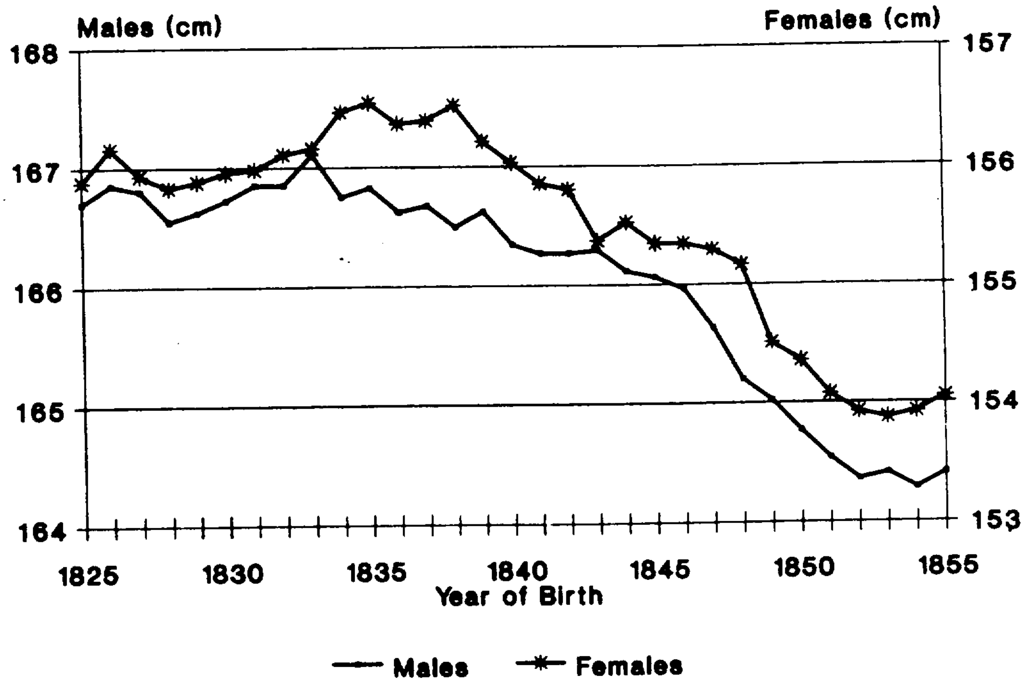


Fig. 6.11 Rural and urban male and female criminal heights, ages 19–49
Source: Alphabetical Register of Habitual Criminals.

(Source: Johnson and Nicholas 1997:222)

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