Essays in Anthropometric History

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Essays in Anthropometric History

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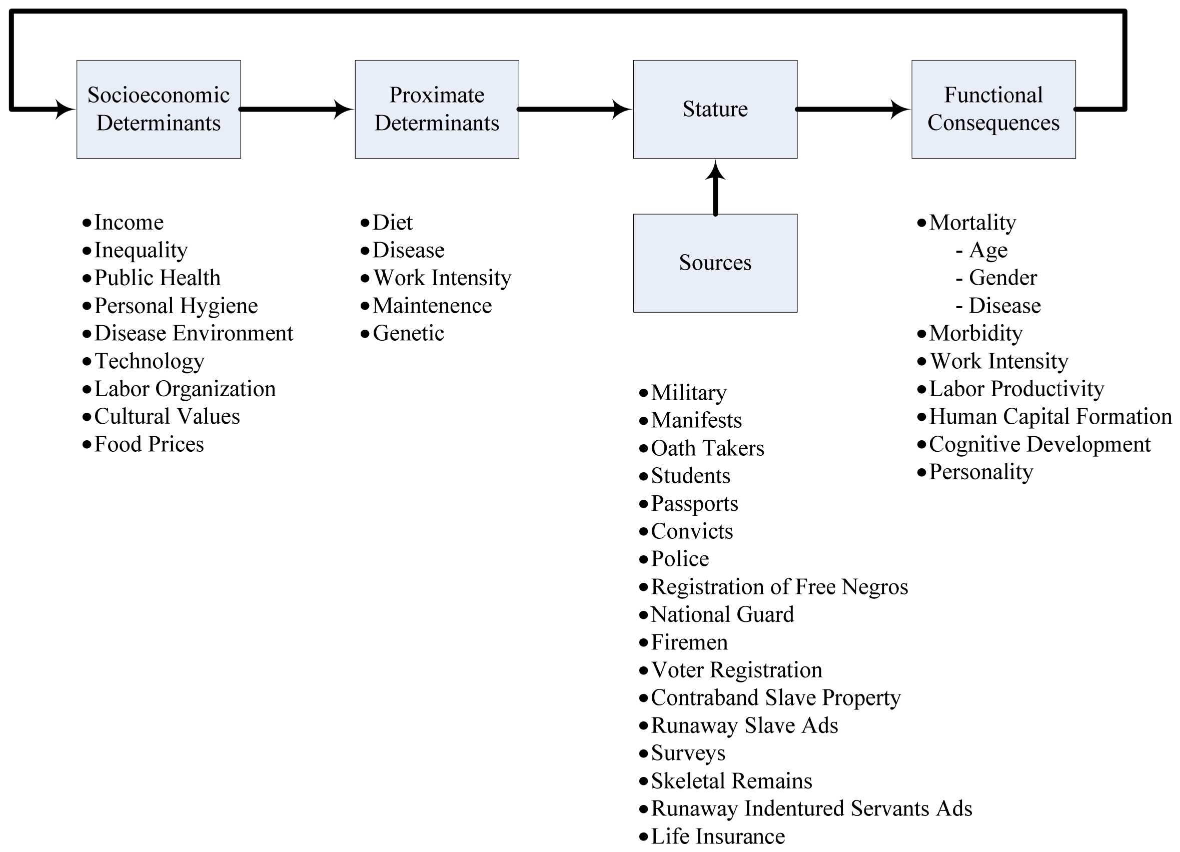
Introductory Remarks

Anthropometric History – the study of human stature and its secular trend – provides a powerful framework for the analysis of interactions between economic and biological processes. Anthropometric History can be defined as “the study of human size as an indicator of how well the human organism fared during childhood and adolescence in its socio-economic and epidemiological environment” (Komlos and Snowdon 2005). Based on medical research that established a clear link between nutritional intake, the disease experience and physical stature, the height achieved by a population indicates the collective net nutritional experience of the individuals composing the underlying population. Mean adult stature reflects the cumulative nutritional status over the course of the years of growth, reaching back into the fetal period (Fogel 1993). While individual height depends largely on the genetic endowment of a subject, the reliance on large samples ensures that genetic differences between individuals cancel out (Steckel 1995, Tanner 1994).

Furthermore, stature is a measure that incorporates difference in the needs between individuals, and thus combines the demand and supply of nutrition, yielding a net measure instead of merely measuring input factors such as income (Steckel 1995). “Diet” or “food consumption”, by itself, is only a gross measure that needs to be supplemented with information regarding the claims on that intake (Fogel 1994). Mean adult height proxies the net nutritional status, that is, nutrient intake after subtracting the claims of workload and diseases on the human body.

Anthropometric data is especially useful when exploring patterns of development in historical settings where other indicators, such as changes in per capita income or real wages, are either unavailable or unreliable, or with respect to populations to whom conventional measures do not properly apply, such as slaves, children and other (Komlos 1991a, Steckel 1995). Since food consumption – the main determinant of nutritional intake – depends on real income, which in turn depends on wages and prices, heights can be used as a proxy for the main contributors to living standards (Komlos 1991b). Figure 0.1 provides an overview over the main factors known to influence physical stature.

Figure 0.1: Relationships Involving Stature



Source: Steckel (1995)

In more recent history, where information on income level exists, anthropometric measures enable us to extend our perception of well-being into non-materialistic dimensions. In developed countries, nutrients are rarely a scarcity anymore; in fact, obesity poses a greater threat to health than malnutrition does. In such a setting, height still captures the biologically relevant component of living standards, as it provides a readily available indicator of health (Komlos and Snowdon 2005). The importance of extending the common materialistic measures of well-being has been recognized and alternative indicators, such as the Human

Development Index (HDI) published by the United Nations (UNDP 2004), which incorporates three dimensions (income, education and life expectancy) into an attempt to broaden the definition of living standards, have been developed. The UNICEF Child Poverty Report 2007 (UNICEF 2007), for instance, ranks the well being of children in rich countries along six dimensions (material well-being, health and safety, education, family relationships, behavior and risks and subjective well-being). The relative position of the respective countries (based on an average rank over the six dimensions) exhibits striking similarities[1] to a ranking based on average heights – and the mere position of the United States and the United Kingdom emphasizes the point that a high per capita income is not enough to perform well (Table 0.1 and Figure 0.2).

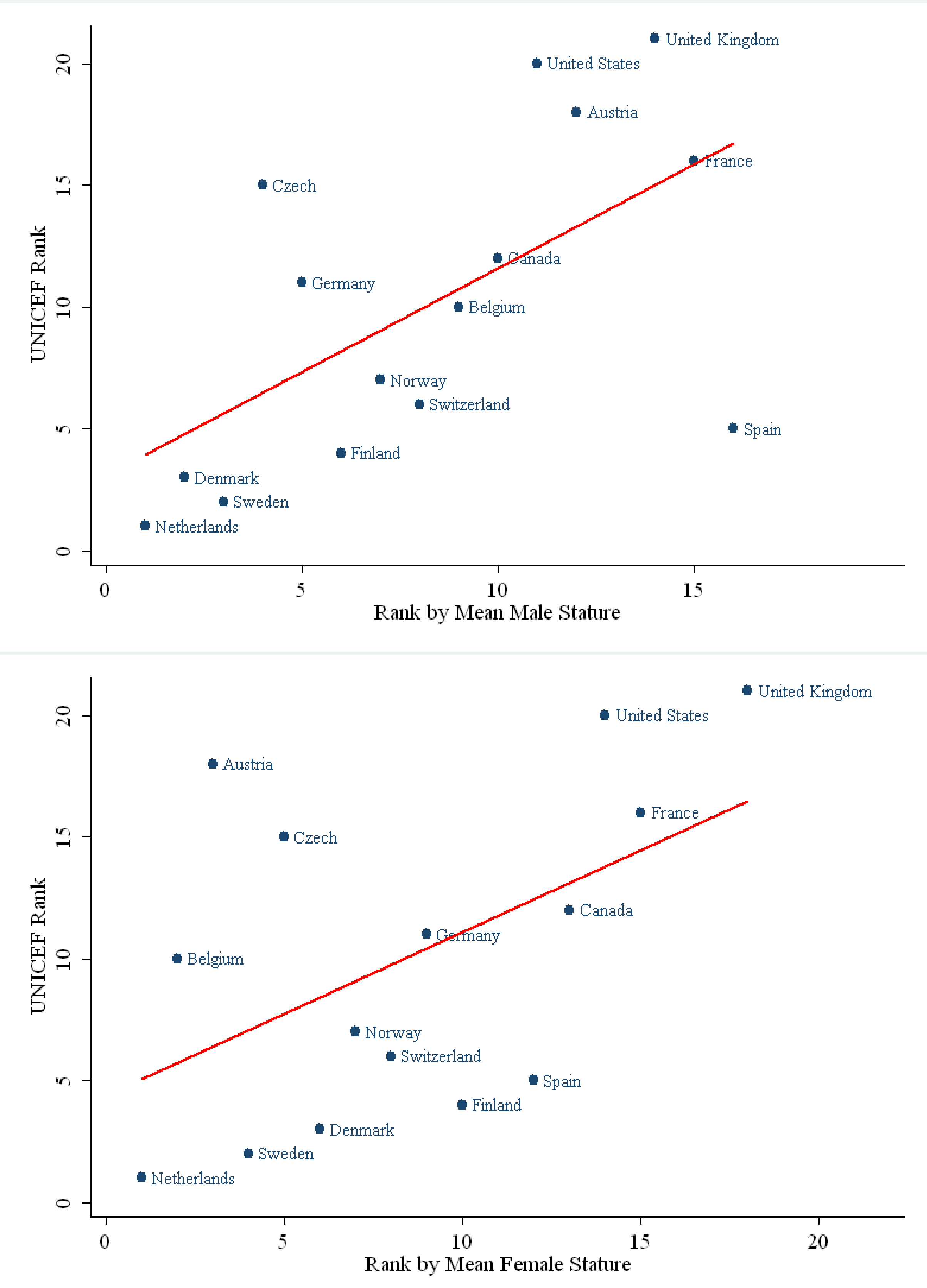
Table 0.1: Children's Well Being and Mean Adult Heights

	Rank Children's Well-Being	Rank Male Adult Mean Height	Rank Female Adult Mean Height
Netherlands	1	1	1
Sweden	2	3	4
Denmark	3	2	6
Finland	4	6	10
Spain	5	16	12
Switzerland	6	8	8
Norway	7	7	7
Belgium	10	9	2
Germany	11	5	9
Canada	12	10	13
Czech	15	4	5
France	16	15	15
Austria	18	12	3
United States	20	11	14
United Kingdom	21	14	18

Source: UNICEF 2007, Komlos 2007

1 Rank correlation, computed by Spearman's ρ, is high (0.65 and 0.52 for males and females, respectively) and statistically significant at the 5% level.

Figure 0.2: Children's Well Being and Mean Adult Height



Sources: UNICEF 2007, Komlos 2007

The research in anthropometric history has brought forth a number of important findings and contributed especially to the debate on the standard of living around the industrial revolution. Economic cycles in the transition can be examined in more detail by mean heights than by real wage series that often lack accuracy and are subject to debate themselves. A first downturn in heights could be shown during the second half of the 18th century in Europe, and a second one in both, Europe and the U.S. during the period from 1830 to 1860.[2] Both of these downturns in height were accompanied by rapid growth of population and industrial output, increasing urbanization and (relatively) slow growth in agricultural labor force and output (Komlos 1991a). The impact of industrial revolution on human stature is remarkable and the decrease in the biological standard of living has therefore been labeled "the hidden costs of economic development" (Cuff 2005).

However, the first decline in European statures in the 18th century actually preceded the industrial revolution. Komlos (1989) argues that the industrialization, by providing the industrial population with additional income that could be exchanged against nutrients, helped to avoid a full-scale Malthusian crisis – that is, bluntly speaking, hunger, famine and starvation (Malthus 1798). In previous periods of rapid population expansion in the 14th and the 17th century, Malthusian constraints had dissipated growth in population and economic output brought about by increasing population. So the industrial revolution provided the means to overcome the effects of the demographic expansion that preceded the industrial revolution (Komlos 1991b).

A second important insight from research in Anthropometric History – and among the earliest ones recognized – is the relatively high nutritional status of American slaves as young adults. While suffering from malnutrition during childhood, adult slaves attained similar heights as

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[2] Americans commonly refer to this period as the antebellum decades.

whites during the 18th and 19th century in the United States. Although legally deprived, slaves' nutritional status was well above the levels of the European peasantry and also superior to African-born blacks (Steckel 1992, Komlos 1994). This knowledge contributed significantly to debate about slavery and put much of the discussion on a more solid ground.

In a cross-sectional perspective, Anthropometric History has contributed significantly to the present day knowledge about differences within populations by gender, socio-economic status and place of birth. Several studies have indicated that the extent to which women were affected by a decline in nutritional status was greater than among men; in catch-up periods, women participated to a smaller degree (Komlos 1991a). Substantial differences exist between upper and lower socio-economic segments: Likely, the most striking example is the 22 cm difference in stature between 16 year old elite-class sons attending the Royal Military Academy at Sandhurst and poor London boys during the middle of 19th century (Komlos 2005). Similar patterns – though not in such extreme levels – have been observed in a multitude of other studies in Anthropometric History. The adverse effects of urbanization are equally well documented, showing a clear disadvantage in the biological component of living standards for urban populations. During the early period of industrialization, proximity to nutrients, as it was typically enjoyed by farmers and alike, as well as distance from markets (i.e. non-integration) have been shown to be correlated with more benign nutritional status (Riggs 1994, Sunder 2004).

In the papers forming this dissertation, four different samples of heights will be analyzed. Two of the papers present the results of an investigation into heights in the United States (or the British colonies preceding it); the other two studies focus on Switzerland. For both of the settings, one study is placed in a historical context and assesses the biological well being at the onset of and during the industrial revolution, while the other paper for each country focuses on more recent experiences during the second half of the 20th century.

The first paper explores the trend in the physical stature of born soldiers born in the New World during the 18th century in colonial British America. Much of the current research about the colonial period is devoted to the question of economic progress at that time. The traditional notion of a prospering economy has been challenged on the basis of new approaches towards measurement of colonial per capita income. In light of this ongoing debate regarding the patterns of economic growth, the paper provides evidence on the timing of economic cycles in the colonial economy. The findings provide a basis for some reconciliation between the conventional theory of a growing economy during the colonial period and the more recently proposed view of stagnation in the levels of per capita output. All direct approaches in the assessment of economic growth in the colonies are faced by a severe paucity of data and hence need to rely on point estimates of output. The information available on soldiers' heights provides a more continuous measure, pinpointing in more detail at periods of both, economic progress and stagnation.

The second paper presents the first estimates on the Biological Standard of Living in Switzerland during the industrial revolution. It provides evidence that Switzerland took part in the widespread decline in nutritional status that accompanied the industrial revolution, even though urbanization and industrial centers were uncommon in Switzerland.

In the third paper, analyzing data on the U.S. Army in 1988, the influence of ethnicity on stature and BMI is investigated. Since anthropometric research generally stratifies by race only, this paper provides important evidence that ethnicity has no significant impact on the average statures in the American melting pot, assuring that the traditional approach of stratification is not biased. The paper furthermore presents evidence on the relative decline of the Biological Standard of Living in the United States in comparison to other industrialized countries: The secular increase in height apparently came to an end in America during the second half of the 20th century, while Europeans continued to grow and eventually overtook Americans, who had been the tallest in the world for more than two centuries.

The fourth and last paper investigates the biological well-being in present day Switzerland. While the level of income inequality in Switzerland is more similar to the United States than to Scandinavian levels, mean stature followed the Scandinavian progress, overtaking Americans during the second half of the 20th century. The different structure of the health care system in Switzerland, leading to exceptional low levels of inequality in health, provided a propitious environment that allowed the Swiss to fare relatively well. This provides valuable results about impact of inequality in income and health on the biologically relevant component of living standards.

While the four papers jointly form this dissertation, each of the papers was designed and written in a manner that allows the reader to read it by itself. While this approach may lead to some repetition, especially in the introductory and methodological sections of each paper, I hope to facilitate the reading for those readers interested in specific topics covered in the dissertation.

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PART I: Standing Tall: Further Evidence on the Biological Standard of Living in Colonial British America

Abstract

This paper uses information on the physical stature of soldiers born in colonial British America in order to assess the Biological Standard of Living in North America during the 18th century. The results show that subjects born in the New World were taller than Europeans throughout the entire 18th century. Even though there was a decline in stature in the early part of the century, an increase of about 2 cm can be shown over the course of the century. This increase is in line with the general trends in mortality and economic growth. The results also show a change in regional differences: While subjects born in the southern colonies were shorter at the beginning of the century, they overtook Northerners during the 18th century and were substantially taller during the second half. Estimates for the influence of socio-economic status provide evidence for a relatively egalitarian society in colonial British America whereas differences increased towards the end of the century. An inferior Biological Standard of Living of subjects born in an urban environment is noted for those born after 1760. In conclusion, the British Colonies in North America offered an exceptionally benign environment, abundant in nutrients and – at least after the initial settlement was completed – favorable in epidemiological regard, leading to an high attainment of stature which was not reached again until the mid-20th century.

Introduction

Assessing the status of living presently relies mostly on material measures, such as per capita income, but alternative measures have also been proposed (Komlos and Snowden 2005). In historical settings, where reliable data on conventional measures is lacking or missing, human height provides a powerful indicator of nutritional status. The average height reached by a population can be interpreted as the cumulative net nutritional experience during childhood and adolescences of the subjects comprising this population. Furthermore, as the nutritional status is related to food consumption, and to the income required to purchase the respective nutrients, it is also related to material measures of the standard of living. The average height also provides information on the health status of subjects, as the epidemiological environment affects the nutritional status when differentiating between the gross nutritional intake – the amount of calories and nutrients consumed – and the net nutritional status, the amount left after any claims of diseases and workload on the human body.

While there is rather broad evidence that the standard of living in late colonial British America was relatively high, quantification is more difficult. The high level of population growth and the large amount of immigration (Fogel 1978 et al., McCusker and Menard 1985, Gemery 2000) support the idea of a generally propitious environment: Malthusian constraints, the historical checks and balances in demographics, were not in place, allowing for high levels of population growth. Nutrients must have been abundant to sustain this. The high level of immigration provides evidence that the overall economic situation must have been more beneficial than in the countries from which the migration originated, as the migrants needed a sufficient incentive to be willing to migrate. This is also supported by a number of studies investigating per capita income in British America placing the income level in the 1770s between $61 and $66 (in 1840 U.S. dollars, McCusker 2000),[3] compared to a typical income of an Englishman at about $44 to $54.8 (Perkins 1980)[4]. Yet quantitative information sustaining this favorable picture remains limited either regionally or temporally (Komlos 2001). Uncertainty about mortality levels, which varied greatly geographically (Gemery

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3 Other estimates, such as Jones' (1980) estimate for 1774 are slightly lower, suggesting values between $ 47.6 and $ 55.6 (converted at a rate of $4.44 per pound sterling), whereas Weiss (1992) provides strong arguments in case of the latter figure.

4 Converted at a rate of $4.44 per pound sterling.

2000), further limits the ability to make general statements about the biological well-being during the 18th century.

In face of the limitations of these commonly used measures of well-being in historical contexts, anthropometric research provides an important framework to learn about trends and differences in the economic status and development of colonial British America and assists in the assessment of the well-being of the respective population, allowing also for a comparison of the Biological Standard of Living in Europe and the American colonies. This paper turns to analysis of the average physical stature of soldiers from the French and Indian War, the Revolutionary War and the early U.S. Army[5] in order to provide quantitative evidence of the level and trends in the Biological Standard of Living in colonial British America.

The Standard of Living in Colonial British America: Demographics and GDP

The most prominent evidence of the dynamic expansion of the colonial British American economy is the rapid growth in population. Starting from 251.000 settlers in 1700, a century later the population had grown by a factor larger than 200 to 5.3 millions (U.S. Bureau of the

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[5] The data on the U.S. army was taken from the Registers of Enlistment in the U.S. Army, 1798-1914, as stored in the Family History Library of the Church of Jesus Christ of Latter-Day Saints, Salt Lake City. The data contains in some cases (1,172 out of 10,723) various alternative entries for the height. Alternative information also exists for age, place of birth and occupation of the soldiers enlisted. The source of these additional pieces of information is unknown to us, but there is a chance that it was added from other data sources to facilitate the genealogical research the data was collected for in the first place. Hence using only the first reported value for each subject is the approach employed in this paper. In order to verify the validity of our estimates, we re-run the regressions using a second and third value for the height of the soldiers and find that our results remain – in the main – unchanged. The magnitudes of some coefficients changes in small amounts, but none of the significant coefficients change sign.

Census 1997). At the time of the Declaration of Independence, the American population accounted for about a third of the British population at that time, and for about 40% of Great Britain's economic output (Perkins 1980).

In addition to the impact of immigration, there is a general agreement that fertility rates were extraordinarily high and well above European levels (Gemery 2000). But even while the natural increase was high, the contribution of immigration was substantial. Over the period from 1700 to 1790, approximately 663.000 people immigrated into the British colonies in North America (Fogel 1986).[6]

Estimates about the level of life expectancy and mortality are harder to come by (Haines 2000), as regional and temporal variations were great. But collecting information from various life tables, Gemery (2000) is confident enough to distinguish the following main trends:

- The overall demographic regime in New England was the most favorable one: Especially subjects living in small inland settlements experienced life expectancies above 45 years, while coastal towns were less benign, providing a life expectancy of about 35 to 37 years. Very little change is noted throughout the course of the 18th century.
- Life expectancy in the Southern colonies was dramatically lower than in New England over the course of the 17th century, but approached New England levels in the Upper South during the 18th century. Evidence for the Lower South is limited, but indicates that the transition took place later than in the Upper South.

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6 Gemery's (2000) estimate is slightly lower at 615.000.

- The conditions in the middle colonies were similar to the experience in New England. The earliest data, partially pertaining to the 17th century, still shows higher levels, but came down over the course of the century.

- A common phenomenon for both, New England and the Middle colonies (no respective data is available for the South) is that port towns had higher levels of mortality than non-coastal settlements. Higher population densities and greater mobility – carrying along sources of disease – is a plausible explanation for this observation.

Contrary to the demographic trends, for which at least a reasonable amount of data could be gathered from colonial censuses, muster rolls, tax lists and the like, estimation of the economic output, per capita income and the changes over time in it depend on estimates of initial and final level, and an interpolation of the growth to account for the change in level. The majority of estimates rely on backward extrapolation of knowledge about the 19th century. McCusker (2000) provides a thorough overview of the estimated levels of per capita GDP in colonial British America. McCusker argues that the greatest level of congruence between the estimates pertains to the benchmark year of 1774. He also attempts to create a new estimate by unifying the previous research after carefully considering the respective methods employed and the arguments in favor or opposed to them. He ends up with an estimated per capita GDP (in 1840 U.S. dollars) of $46 in 1720, growing at a rate of on average 0.6% to $66 in 1774, and again at $66 in 1800, after recovering from the double-dip recession from 1778 to about 1790. If the period from 1720 to 1800 is considered, the estimated average annual growth rate was near 0.4%, lower than the estimate for the 1720-1774 period because of the kink in the growth curve due to the post-revolutionary war recession. Despite the – in modern terms – relatively low level, the economic growth rate experienced by the British colonies in North America was probably higher than in most of the rest of the world: Only Great Britain, Holland and France enjoyed similar rates of development (McCusker & Menard 1985, McCusker 2000). Yet it must be recalled that these estimates are only “estimates of the most approximate nature” (Mayhew 1995, cited in McCusker 2000).

The notion of economic growth in colonial British America has been questioned by Mancell and Weiss (1999). Using conjectural estimates on the value of the output, they conclude that the level of per capita output growth among colonists was close to 0.04% over the course of the century. They agree with other studies that growth was faster during the first half of the century than in the latter half. 1750-1770 is the subperiod with the highest growth rate of 0.14%, and they also point out an economic downturn between 1770 and 1800. Their estimate, however, hinges on the assumption that the value of the food consumption – which constitutes almost half of the estimated per capita GDP – remained constant.[7] Exploring alternative patterns, Mancall and Weiss acknowledge that a modest annual growth rate in food consumption of 0.4%[8] would lead to an overall economic growth of 0.31% over the entire century, placing their modified estimate within (but at the bottom) of the traditional range of estimates for the growth rate.

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[7] In a similar essay considering the lower south only, Mancell et al. (2000) allow for increases in food consumption of 0.25% p.a., but start at a significantly lower level of value of the food consumed in 1700.

[8] Mancall and Weiss argue that such growth rates in food consumption were unlikely, as an annual increase in agricultural productivity of 0.35% - a rate in excess of the estimates for the early 19th century – would be required to sustain this. Yet it remains questionable if those periods are comparable, since the 18th century was still marked by extensive clearing of land that may have been accompanied by faster growth in agricultural productivity.

As physical stature is a function of the nutritional intake and food consumption, height data should be able to shed some light on this controversy. A constant level of food consumption should lead to a stagnating level of height, while a continuing increase in consumption would be accompanied by increases in physical stature.

The Alternative Approach: Previous Research on Colonial Heights

The analysis of heights during the 18th century in colonial British America was among the very early work in anthropometric history, and provided quite surprising results. Sokoloff and Villaflor (1982), using data drawn from muster rolls of the French and Indian War and the Revolutionary War, noted that the level of average stature of these soldiers was rather close to the modern level: Soldiers who fought in the Revolutionary war were nearly as tall (68.1 inches or 173 cm) as those who fought in World War II. Soldiers from the French and Indian War were only slightly shorter. Sokoloff and Villaflor report that the height of these groups exceeded the height of the British Royal Marines by about 3.0 to 3.5 inches (7.6 to 8.9 cm).[9] They conclude that a difference in the genetic potential between the European population and its emigrated kin in colonial British America are unlikely and implausible, as genetic changes take very long time. Therefore, the height advantage in the colonies seems to be related to a higher nutritional status. While Sokoloff and Villaflor admit that the knowledge of the American diet during that time is slim, they provide some evidence that larger quantities of meat were eaten in the colonies than it was commonly in England. Meat is

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9 The English heights used by Sokoloff and Villaflor have been questioned: They do not take systematic discrimination against tall men, a common practice in the Royal Marine Society, into account. Komlos (2001) reports a difference of -0.2 and 1.7 cm in 1720. Komlos and Cinnirella (2005), on the other hand, investigate British soldiers serving in the armies of the American British Colonies and report English-born subjects' height in the vicinity of 167.5 cm (66 inches) for the period from 1710-1720. This implies a difference of 2.1 inches.

especially important for the growth process, as it is rich of proteins, which are especially important to the human growth process (Komlos 1989). Sokoloff and Villaflor stress that “the value of the nutritional value of the diet does not appear to have varied substantially over social (occupational or urban-rural) class”, and hence the overall level of equality must have been rather high. Regional factors account for greater differences: While New England and the Middle Atlantic remained rather similar, Southerners enjoyed a height advantage throughout the entire period of observation.

Yet the analysis of Sokoloff and Villaflor has its disadvantages, as they also include subjects that were not born in the New World in their analysis. Fogel (1986), assessing the impact of changes in nutritional status on mortality and life expectancy, returns to the Sokoloff and Villaflor data but considers only subjects that were born in America. He finds a constant level of mean terminal height for the period from 1710 to 1755. While the quinquennial means fluctuate slightly, they stay within the range of 171.5 cm to 172.2 cm. There is no data available from 1755 to 1780, but the level by 1780 is at 173.2 cm, requiring an increase of more than 1 cm in for the time period without data. The course of this increase, however, cannot be assessed. Beginning in 1780, Fogel shows that heights of soldiers born in America were affected by a light downturn in mean height, decreasing to 172.8 cm at the turn of the century. No further discussion of spatial or socio-economic differences in mean height is included.

Steegman and Haseley (1988) use records on soldiers who fought in the French and Indian War to estimate a mean stature among those born in colonial British America from 1720 and 1740 at 171.6 cm. They do not provide information on a longer period of time so no trend can be derived from their results. They analyze regional differences based on climatic zones, and find that subjects born in non-coastal New England and the mid-Hudson valley were tallest at 173.5 cm, followed by (in the main) western Massachusetts, upstate New York, coastal New

England, New Jersey and Pennsylvania with a height level about 170.1 cm to 171.6 cm. The shortest subjects are from the Philadelphia area, Delaware and eastern Maryland, who were 169.2 cm tall.[10] This unique specification of a spatial pattern employed by Steegmann and Haseley is of great interest and more detail than any other study, however, it prevents a direct comparison of the spatial effects with most other studies that analyze differences in stature by region or colony of birth.

Komlos (2001) investigates the biological welfare during the 18th century America using information on runaway apprentices and military deserters. He also finds that colonial born subjects were significantly taller than their European counterparts: by 1780, Americans enjoyed a height advantage of 6.6 cm. The analysis of changes in stature during the 18th century corroborates the findings by Sokoloff and Villaflor: Heights decreased during the first half of the century (including those born in the 1740s) by 4.3 cm to a level of 169.6 cm and increased steadily afterwards till the Revolutionary War. The shortcoming of this data set is that it is based on runaways and therefore may not be representative of all soldiers. Hence, the trend in height among soldiers born in colonial British America is worth further exploration.

Data and Method of Analysis

We add further to the understanding of both level and trends in the biological standard of living in early British America by analyzing data compounded from muster rolls and recruitment lists collected during the French and Indian War, the Revolutionary War as well as the War of 1812 (see appendix I for a list of the source documents). The data include,

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10 The number of subjects born in colonial British America for all climatic zones but western Massachusetts and upstate New York (N=54) is larger than 100 and should be large enough for such a spatial analysis.

Table 1.1: Characteristics of the Native Born Sample

	Full Sample		Early Sub-sample (1700-1755)		Latter Sub-sample (1756-1800)	
	N	%	N	%	N	%
Birth Cohort						
1700-1715	62	0.50	62	1.67		
1716-1720	105	0.85	105	2.83		
1721-1725	148	1.19	148	3.99		
1726-1730	282	2.27	282	7.60		
1731-1735	814	6.56	814	21.93		
1736-1740	1045	8.42	1045	28.16		
1741-1745	999	8.05	999	26.92		
1746-1755	256	2.06	256	6.90		
1756-1770	306	2.47			306	3.52
1771-1775	430	3.47			430	4.94
1776-1780	923	7.44			923	10.61
1781-1785	1,036	8.35			1,036	11.91
1786-1790	1,982	15.97			1,982	22.79
1791-1800	4,019	32.39			4,019	46.22
Subject's Age						
15 years	48	0.39	3 [a]	0.08	45	0.52
16 years	210	1.69	92	2.48	118	1.36
17 years	383	3.09	223	6.01	160	1.84
18 years	995	8.02	351	9.46	644	7.41
19 years	811	6.54	365	9.84	446	5.13
20 years	779	6.28	349	9.40	430	4.94
21 years	1,403	11.31	379	10.21	1,024	11.78
22 - 49 years	7,731	62.31	1934	52.12	5,797	66.66
over 50 years	47	0.38	15	0.40	32	0.37
Subject's Birthplace						
Connecticut	1034	8.33	320	8.62	714	8.21
Delaware	92	0.74			92	1.06
Georgia	73	0.59			73	0.84
Kentucky/ Tennessee	156	1.26			156	1.79
Massachusetts	1,432	11.54	91	2.45	1,341	15.42
Maryland	771	6.21	222	5.98	549	6.31
North Carolina	692	5.58	8 [b]	0.22	684	7.87
New England - unspecified	166	1.34	165	4.45	1 [a]	0.01
New Hampshire	552	4.45	1 [a]	0.03	551	6.34
New Jersey	660	5.32	155	4.18	505	5.81
New York	2,298	18.52	1,098	29.59	1,200	13.80
Pennsylvania	1,181 [c]	9.52	173	4.66	1,008 [c]	11.59
Rhode Island	189	1.52	78	2.10	111	1.28
South Carolina	343	2.76	11 [b]	0.30	332	3.82
Virginia	2,071	16.69	1,024	27.59	1,047	12.04
Vermont	274	2.21			274	3.15
not specified	423	3.41	365	9.84	58	0.67
Subject's Region of Birth						
New England	3,647	29.39	655	17.65	2,992	34.41
Mid-Atlantic	5,002	40.32	1648	44.41	3,354	38.57
Upper South	3,011	24.27	1,032 b	27.81	1,979	22.76
Lower South	416	3.35	11 b	0.30	405	4.66
Unknown	423	3.41	365	9.84	58	0.67
Urban - Rural						
Rural	11,863	95.62	3,707	99.89	8,156	93.79
Urban	544	4.38	4 [a]	0.11	540	6.21
Subject's Socio-economic class						
White Collar	207	1.67	26	0.70	181	2.08
Misc. Crafts	4,217	33.99	1,374	37.03	2,843	32.69
Farmer	4,062	32.74	946	25.49	3,116	35.83
Unskilled	2,604	20.99	1,188	32.01	1,416	16.28
Unknown	1,317	10.61	177	4.77	1,140	13.11

Notes: [a] omitted from regression because of small N. [b] SC and NC were pooled in the early subsample because of small N. [c] includes 12 subjects from Ohio and 8 subjects from Michigan.

Source: see appendix I

among others, information on the name of the soldier, his profession, height,[11] the place of enlistment and the place of birth (sometimes the state, the county or the precise location), the age at enlistment and the date of enlistment. Using the information on the age at and date of enlistment, the birth year of the subject was calculated. The information on the profession of the subject was used to categorize the subject into a socio-economic class following the scheme devised by Armstrong (1972). In order to have more uniform information, the birthplace information was converted to state-level for all subjects where it was possible. Subjects from counties and locations with names that existed in different states were related to a specific state if an assessment of the enlisting organization allowed this. If this was not possible, the subject's birthplace was coded as unknown. Coding subjects properly as urban born is made difficult by the quality of the data: In order to be sure that only truly urban subjects were included, only those who reported one of the major cities at that time (Boston, Philadelphia, New York and Baltimore) as the precise location of their birthplace were coded urban. All others were treated as rural born (Table 1.1).

We need to inspect our data for any anomalies that might arise from contemporary recruitment practices, such as heaping of the data and truncation of the sample due to minimum height requirements (MHR) of the military (Komlos 2004a). As the height requirements might have changed over time, we split our dataset into three different recruitment groups: The first group contains the subjects recruited 1753 – 1765 (N=7,979). This group constitutes the French and Indian War recruitment sample. As we have only a limited number of subjects that joined the military during the Revolutionary War, group 2,

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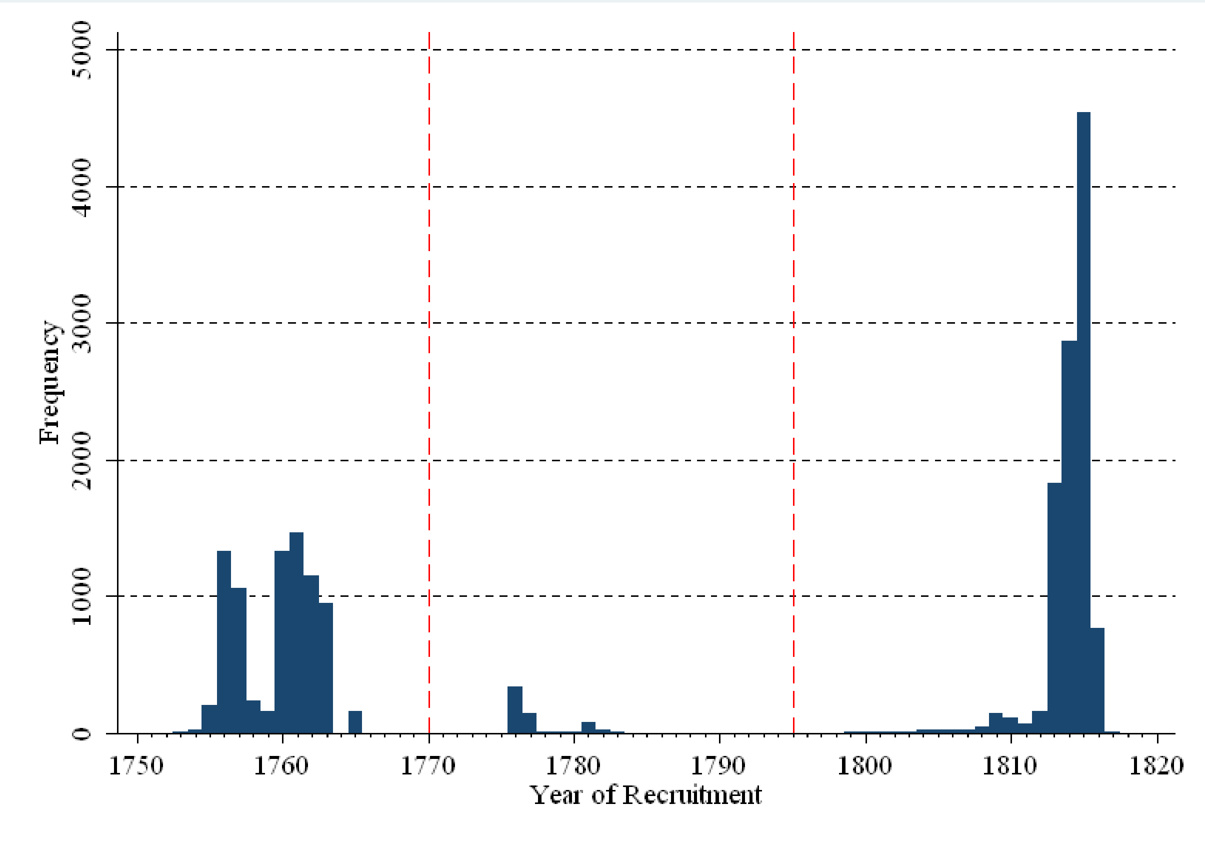
[11] Of the measurements in our data, there are 3% on both quarter-inch level (0.25 and 0.75), 19% on the half-inch level and the remainder of 75% rounded to full inches

including all subjects enlisted between 1776 and 1783, is relatively small (N=587).[12] Our third and last recruitment group includes subjects mostly recruited during the War of 1812 and ranges from 1800 to 1816 (N=10,607, see Figure 1.1).

Figure 1.1: Distribution of Recruitment Years



Source: see appendix I

An analysis of the minimum height requirement can be done most easily by a visual inspection of the histograms of the data.[13] We supplement the histograms with a normal density plot as well as a kernel density estimate in order to facilitate the assessment of normality (Figure 1.2).

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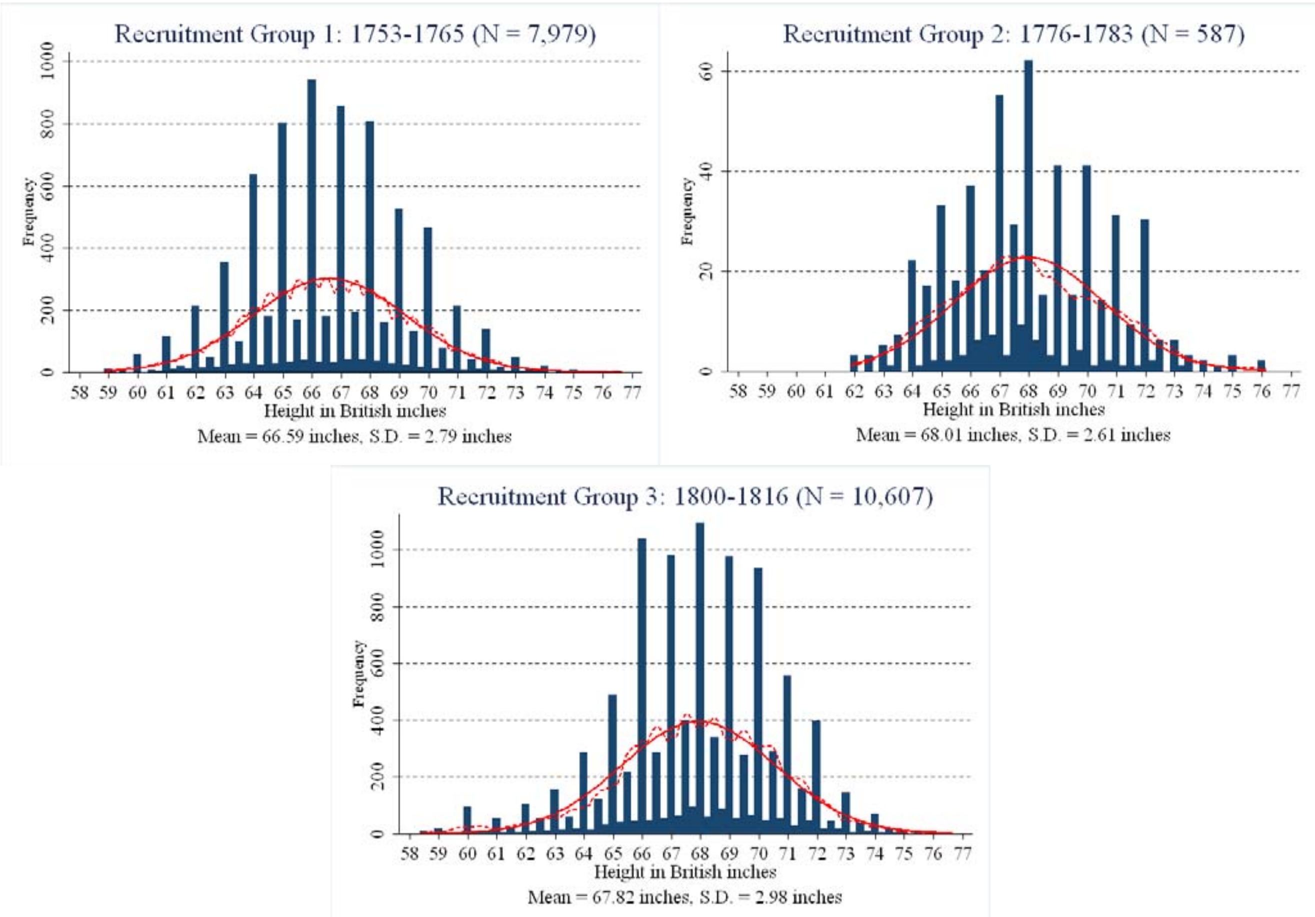
[12] Smaller samples will have less a normal distribution than larger groups, which must be taken into account when determining any potential truncation of the sample.

[13] Computational methods also exist (Heintel 1996), but the results are not superior to those obtained by visual inspection (Komlos 2004a).

In all three groups, a large amount of heaping is evident. The extent of heaping varies between the recruitment groups, indicating that either more refined measurement methods were used in later periods, or greater attention to precise measurements was given. In any case, heaping should not seriously distort our results, as the upward and downward rounding effects should cancel out as far as rounding to the nearest half or full inch is concerned.

Figure 1.2: Histograms of Height Distribution by Recruitment Group



Source: see appendix I

Recruitment group 1 does not show any shortfall due to a MHR in the distribution. Recruitment group 2 appears to be affected by truncation below the level of 64 inches. One also might be concerned about truncation in recruitment group 3 at a level of 66 inches, as the increase from 65 to 66 inches is greater than expected.[14] Yet in face of the large number of observations at 64 inches and below, and the decline in observations from 66 to 67 inches, the relatively high frequency at 66 inches seems to be influenced by random disturbances. Consequently, we feel comfortable using Ordinary Least Squares (OLS) regression as no serious deficiency from truncation seems to distort the distributions. Nonetheless we will add estimates using Truncated Maximum Likelihood Estimation (TMLE) for recruitment groups 2 and 3 in order to estimate the potential impact of truncation at the points discussed above.[15]

For the analysis of the data, we limit our attention to those recruits that were born in colonial British America or the U.S. (the "native-born sample"). This limitation is important, as the nutritional experience during childhood and adolescence would have been significantly different for this group. Hence, the native-born subjects and the foreign-born ones constitute distinct different populations and should not be intermixed in the analysis.

The number of observations fluctuates greatly by year of birth. In our native-born sample, the number of observations born in the early 18th century as well as in 1745 to 1770 is relatively low (Figure 1.3). If the results for this period deviate excessively from the results for the remainder of the sample, this might be due to small sample bias. While we will be using quinquennial birth cohorts for all the periods with sufficient observations in the regression analysis, we will use larger birth cohorts at the beginning and the end of the century as well as for the period from 1745 to 1770.

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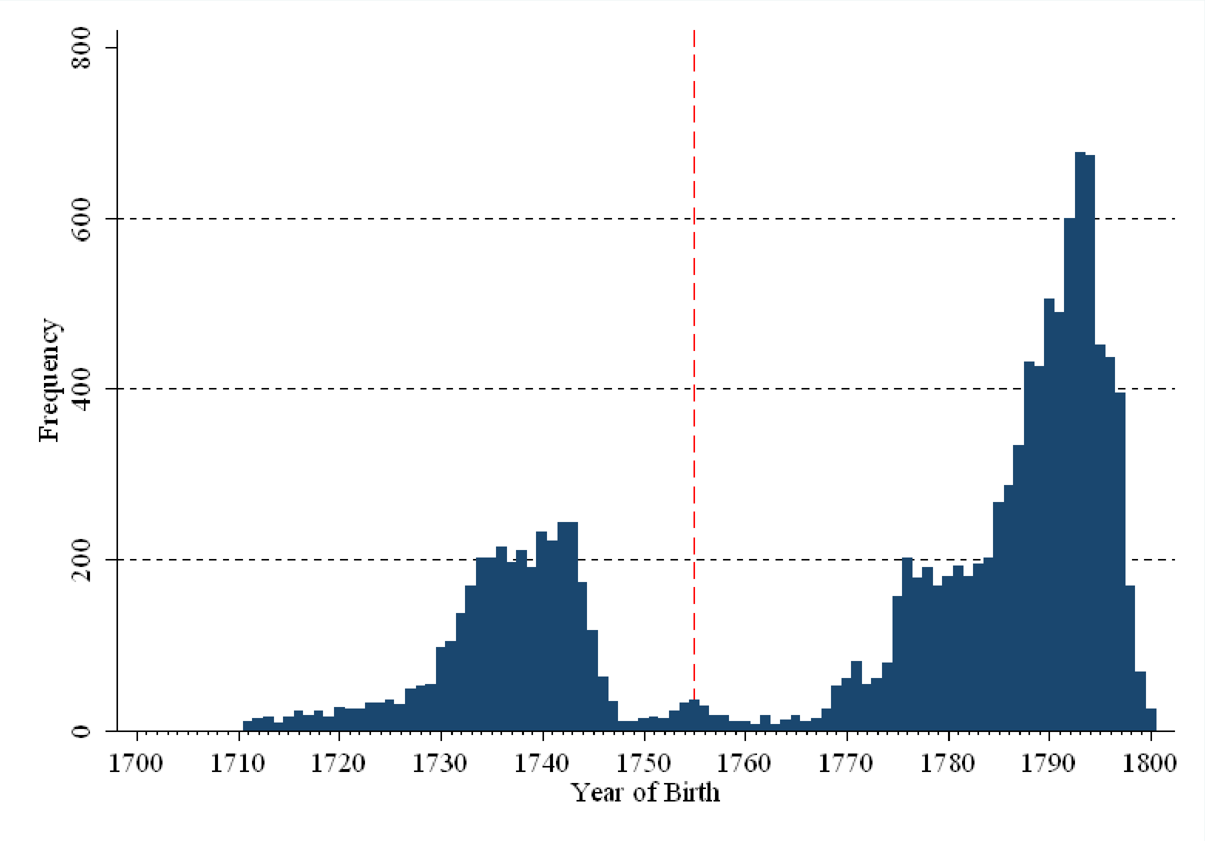
14 Even though the distribution looks somewhat 'boxy', more detailed analysis based on annual histograms showed that the distribution is not the sum of two different normal distributions.

15 OLS and TMLE (incl. constrained TMLE) analysis were performed using the statistical software package STATA 9.1.

Figure 1.3: Distribution of Native-Born Subjects' Years of Birth



Source: see appendix I

For our estimation, we initially regress the height of the subjects on dummy variables for the birth cohorts and controls for the ages below 22, as our dataset includes youth that have not yet completed their growth process. A control variable for those above the age of 50 is also added, as old-age related shrinkage might have begun for those subjects (Model 1). We also add variables for the birthplace (aggregated to state level) and whether the subject was urban born (Model 2). In the next specification, we replace the birthplace with dummies for the occupation class of the subject (Model 3), and then add the state of birth again (Model 4). Since occupational mobility was rather low in colonial British America during the 18th century (Perkins 1980), the occupation of the subject is a good proxy for the occupation of the father and hence serves as indicator for the socio-economic environment the subject grew up in.

Finally, as the number of observations around 1755 is relatively low, we split the sample at that year into time periods that will be analyzed separately, using the setup of specification 4

(Model 5 and Model 6) for the early and latter sub-sample, respectively). Additionally, we define alternative specifications for both sub-sets, replacing the information about the state of birth by regional dummies (Model 5a and Model 6a). This is done in order to estimate different effects of regional and socio-economic factors. Since we have to rely on dummy variables for these covariates in our OLS and TMLE regression, we would estimate a constant influence of these factors throughout the entire period. Changes in the impact of these covariates over time are likely, however. Also, due to the geographical expansion the latter period includes subjects from a larger region than the early period.

A common problem associated with the use of dummy variables in order to allow for nonlinearity in the impact of the year of birth is excessive variation due to over-parameterization of the model estimated. Several methods to penalize such excessive variation exist; here we supplement the OLS estimation findings with results from a nonparametric Bayesian estimation procedure using the statistical software BayesX.[16]

Results

OLS Regression Results

As the other studies noted above we also find that the native-born population was very tall for the times. Throughout the century (with the exception of the last quinquennium), the estimated stature ranges from 171.5 and 175.0 cm, with an average near 173 cm (Table 1.2[17] and Figure 1.4).

[16] For an extended discussion of the details of this estimation procedure, see Lang and Sunder (2003).

[17] In order to facilitate the reading of this paper, we present an abbreviated version of the results in Table 1.2. The full results of the estimation are included in appendix II.

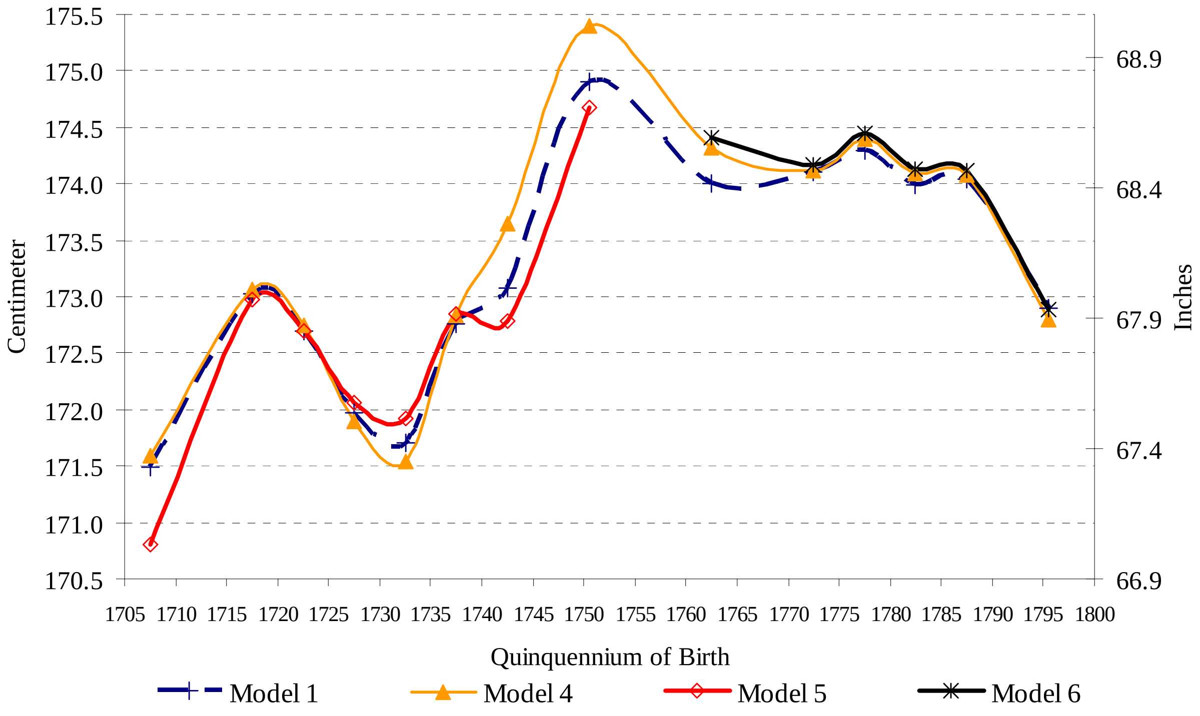
Table 1.2: OLS Regression Results Dependent Variable: Height of Native Born Soldiers

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 5a	Model 6	Model 6a
Birth Cohort								
1700-1715	-1.59**	-1.94**	-1.87**	-2.06***	-1.98**	-2.10**		
1716-1720	-0.06	-0.45	-0.36	-0.59	0.20	-0.01		
1721-1725	-0.38	-0.75	-0.69	-0.90	-0.08	-0.39		
1726-1730	-1.11**	-1.54***	-1.52***	-1.75***	-0.72	-1.11**		
1731-1735	-1.38***	-1.84***	-1.88***	-2.11***	-0.86*	-1.28***		
1736-1740	-0.32	-0.62*	-0.64**	-0.81**	0.07	-0.14		
1741-1745	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.		
1746-1755	1.82***	1.86***	1.67***	1.75***	1.90***	1.77***		
1756-1770	0.92**	0.97**	0.61	0.67			0.30	0.24
1771-1775	1.02**	0.80*	0.68*	0.47			0.05	0.02
1776-1780	1.22***	1.05***	0.96***	0.74**			0.33	0.30
1781-1785	0.91***	0.73**	0.66*	0.44			0.02	0.01
1786-1790	0.96***	0.73**	0.69**	0.43			Ref.	Ref.
1791-1800	-0.18	-0.55*	-0.51*	-0.85***			-1.22***	-1.20***
Subject's Age								
15 years	-17.43***	-17.53***	-17.50***	-17.54***	0.00		-18.17***	-18.09***
16 years	-10.27***	-10.52***	-10.34***	-10.50***	-7.84***		Ref.	Ref.
17 years	-6.36***	-6.47***	-6.49***	-6.56***	-5.62***		-7.32***	-7.26***
18 years	-4.34***	-4.50***	-4.49***	-4.57***	-3.64***		-4.87***	-4.83***
19 years	-2.61***	-2.75***	-2.76***	-2.81***	-2.90***	-3.08***	-2.45***	-2.46***
20 years	-0.64**	-0.81***	-0.79***	-0.85***	-1.25***	-1.39***	-0.34	-0.29
21 years	0.10	0.02	0.03	-0.01	0.07	0.01	-0.06	-0.04
22 - 49 years	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
over 50 years	-1.20	-1.28	-1.15	-1.35	1.06	1.30	-2.44**	-2.31**
Subject's Birthplace								
CT		-0.49**		-0.55**	-0.55		-0.33	
DE		-2.93***		-2.83***			-2.28***	
GA		1.27		1.04			1.49*	
KY / TN		2.19***		2.09***			2.65***	
MA		-0.27		-0.33	-1.84***		0.25	
MD		-0.45		-0.53*	-1.40***		0.16	
NC		0.55*		0.39			0.89***	
New England - unspecified		-1.11**		-1.03*	-1.76***			
NH		0.70**		0.53*			1.09***	
NJ		-1.06***		-1.02***	-1.24**		-0.58*	
NY		Ref.		Ref.	Ref.		Ref.	
PA		-0.57**		-0.55**	-1.65***		0.07	
RI		0.03		0.04	0.20		-0.02	
SC (incl. NC in Model 5)		0.62		0.46	-3.35**		1.10**	
VA		0.29		0.10	-1.51***		1.24***	
VT		0.56		0.30	0.00		0.85*	
not specified		-1.23***		-1.21***	-1.82***		0.18	
Subject's Region of Birth								
New England						-0.52*		0.42**
Mid-Atlantic						Ref.		Ref.
South						-0.90***		
Upper South								1.33***
Lower South								1.26***
Unknown						-1.42***		0.32
Urban - Rural								
Rural		Ref.	Ref.	Ref.			Ref.	Ref.
Urban		-2.81***	-2.90***	-2.74***			-2.60***	-2.43***
Subject's Socio-economic class								
White Collar			0.74	0.68	2.42	2.30	0.53	0.55
Farmer			0.73***	0.54***	0.27	0.22	0.75***	0.80***
Skilled			Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Unskilled			-0.49***	-0.47***	-0.76***	-0.68**	-0.51**	-0.53**
Unknown			0.29	0.23	-1.53***	-1.98***	0.58**	0.60**
Intercept	173.08***	173.63***	173.36***	173.86***	173.96***	173.73***	173.64***	173.49***

* Significant at the 10% level ** Significant at the 5% level *** Significant at the 1% level

Source: see appendix I

Figure 1.4: Time Trend in Height



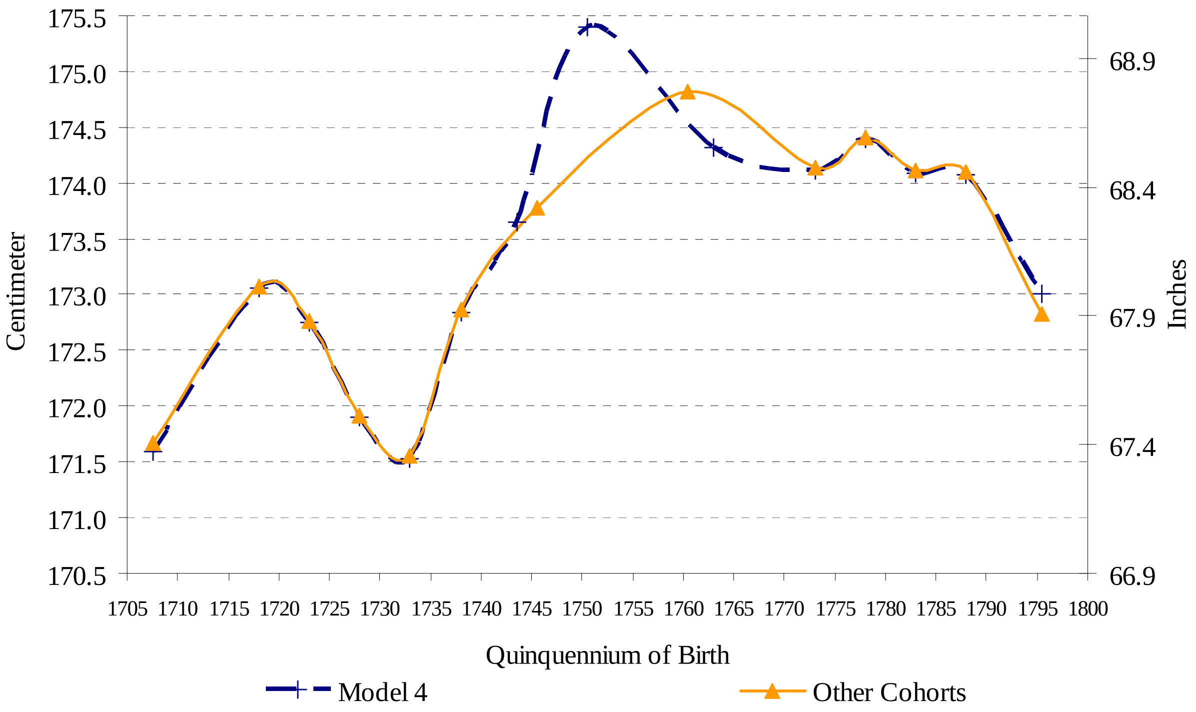
Source: Table 1.2
Note: Graphs show estimated adult heights after taking weighted averages for place of birth and socio-economic status.

The overall tall stature in the late colonial America and the early United States – 174.3 cm, the level attained during the third quarter of the 18th century is the 35th percentile modern stature in the U.S. – leaves the 18th century native born subject a mere 2.5 cm shorter than Americans in 1950 and about 5.0 cm shorter than Western Europeans today (Steckel 1996, Komlos and Lauderdale 2007).

The trend in mean height (as measured by model specification 1) over the course of the 18th century exhibits a downturn of 1.3 cm from 173.0 cm to 171.7 cm over the period from 1715 to 1735 with a nadir during the early 1730s. An increase to a peak at about 174.8 cm at the middle of the century followed. The level of height remained relatively stable in the vicinity of 174.0 cm into the late 1770s, and began to decline with those born in the late 1780s, reaching a larger amount of decline in the 1790s.[18]

Both, the small number of observations at the middle of the century and the excessive increase from 1740 to 1750 create some doubt about the exact placement of the apex in height. In order to establish a bandwidth between an upper and lower bound for the physical stature and a range for the time when the peak during the middle of the century was reached, we modify the estimates by replacing the dummies for the three cohorts 1741-45, 1746-55 and 1756-70 by two cohorts for 1741-50 and 1751-70 (Figure 1.5).

Figure 1.5: Time Trend in Height – Alternative Cohorts



Source: Table 1.2, calculations based on data from appendix I

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18 Our estimate of the trend in height at the end of the century is problematic, as the 1790-1800 birth cohort includes a large number of youths. In order to account for this situation, we re-ran the regressions using only adult (aged 21 and older) subjects. This limits our data to those born before 1795, but it confirms the extent of the decline during the last decade of the century.

As we expect, the new combination leads to a much smaller estimate of stature for 1741-50, since this estimate is dominated by the share born in the first half of the decade. The estimate for the second new cohort (1751-70) shows an intermediate level of height compared to the estimates for the surrounding birth cohorts in model 4. So while the data available to us is not good enough to pin-point the zenith in stature exactly, there is solid evidence that heights peaked between 1750 and 1770 at a level of 174.8 cm to 175.4 cm.

The observed time trend in height favors somewhat the McCusker-Menard view of economic development during the 18th century, pointing to some increase in real per capita incomes beginning in the 1730s (McCusker 2000, McCusker and Menard 1981). While the disease environment in this mostly rural stetting remained favorable, the net nutritional status increased after 1730, indicating increases in the amount (and value) of food consumed by the colonists. This result raises some doubts about the low estimates of economic growth for this period by Mancall and Weiss, which rely heavily on the assumption of constant levels of food consumption. But the improvements in height were confined to the first half of the century; stature stagnated, or even declined during the second half of the century, supporting to some degree the Mancall and Weiss view of a stasis in economic growth during the second half of the 18th century (Mancall and Weiss 1999).

Yet even while the observed trend is mostly stable, the differences in the timing of up- and downswings between Fogel's (1986) and Komlos' (2001), and the present estimates deserve discussion (Figure 1.6): With respect to the time period from 1720 to 1750, all three studies support the same pattern. Komlos's (2001) data on military deserters shows the nadir in height for those born in the decade of 1740, with an average height of 169.8 cm.[19] However, the data

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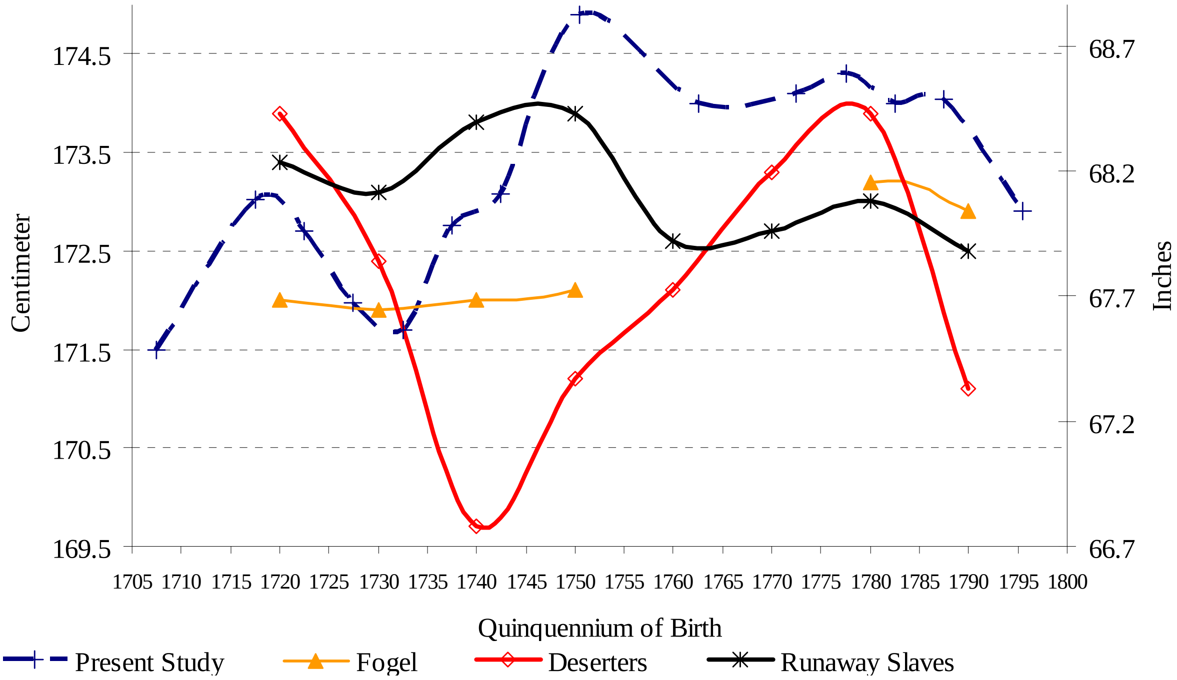
[19] Komlos subtracts 0.5 cm from his data to allow for the possibility that heights reported were the heights with boots on, which neither of the others do.

used by Komlos is not representative and may be biased in that cohort. Fogel, on the contrary, returning to the data used by Sokoloff and Villaflor, reports a relatively flat trend, exhibiting some fluctuation, but no secular trend in either direction. Unfortunately, he does not provide a description of the estimation method used, so a direct comparison is not possible.

Figure 1.6: Time Trend in Height – Comparison with Previous Studies



Source: Table 1.2, Fogel (1986), Komlos (2001), Komlos (1994)

Yet the exact timing set aside, the main trend observed in each of the studies analyzing whites is similar. The trend in the heights of runaway slaves (Komlos 1994) is much less fluctuating than the experience of whites and shows a decline in stature at the transition from the first half of the century into the second.

The trend in the second half of the 18th century is similar among the previous studies: An increase in physical stature from 1740 to 1790s, with an onset of decline in the 1790s. Even though Sokoloff and Villaflor and Fogel do not show an exact trend, but provide information on the level at both, mid-century and in the 1780s, the difference between the levels calls for an increase. Yet they do not provide a trend between 1750 and 1780, so the details of the transition are unclear. Our results differ during the first half of the century in showing a notable decline in heights in the 1730s, while Sokoloff and Villaflor only indicate a very marginal increase (Sokoloff and Villaflor 1982 Figure 3) But the estimated levels in stature in the Sokoloff and Villaflor's study and the present data are similar in both periods Sokoloff and Villaflor show. Komlos shows in the detail that mean stature increased monotonically from decade to decade between 1740 and 1780. The results in the present study, however, suggest a downturn in mean height during the second half of the 18th century, or at best a stagnating level. The important difference between Komlos' result and the present data is that heights in our data do not decline during the 1740s, but show a clear increase during thre1740s. Apparently, the runaway sample analyzed by Komlos seems to be biased in the 1740s: A decline during the beginning of the century, hitting bottom during the 1730s and increasing height afterwards seems to be the prevailing trend in North American heights in the 18th century.

The regional pattern in the height differences (Figure 1.7) shows the need to divide the sample into two sets pertaining to different periods.[20] While southerners, in the main, suffered from a notable height deficit compared to the middle colonies and New England in the first half of the 18th century, the pattern reversed in the second half of the century.

For the time period from 1700 to 1755, the tallest soldiers were born in Rhode Island (174.0 cm) and New York (173.8 cm). There was a clear North-South gradient, with the exception of Massachusetts (171.9 cm), which was closer to the level of the southern Mid-Atlantic States (172.1 cm – 172.5 cm), Virginia (172.2 cm): Men from the Carolinas were shortest with 170.4 cm, leaving them more than 3 cm smaller than New Yorkers and Rhode Islanders; the coefficient is statistically significant even though the number of subjects in our sample that were born in the Carolinas in this period is small (N=19).

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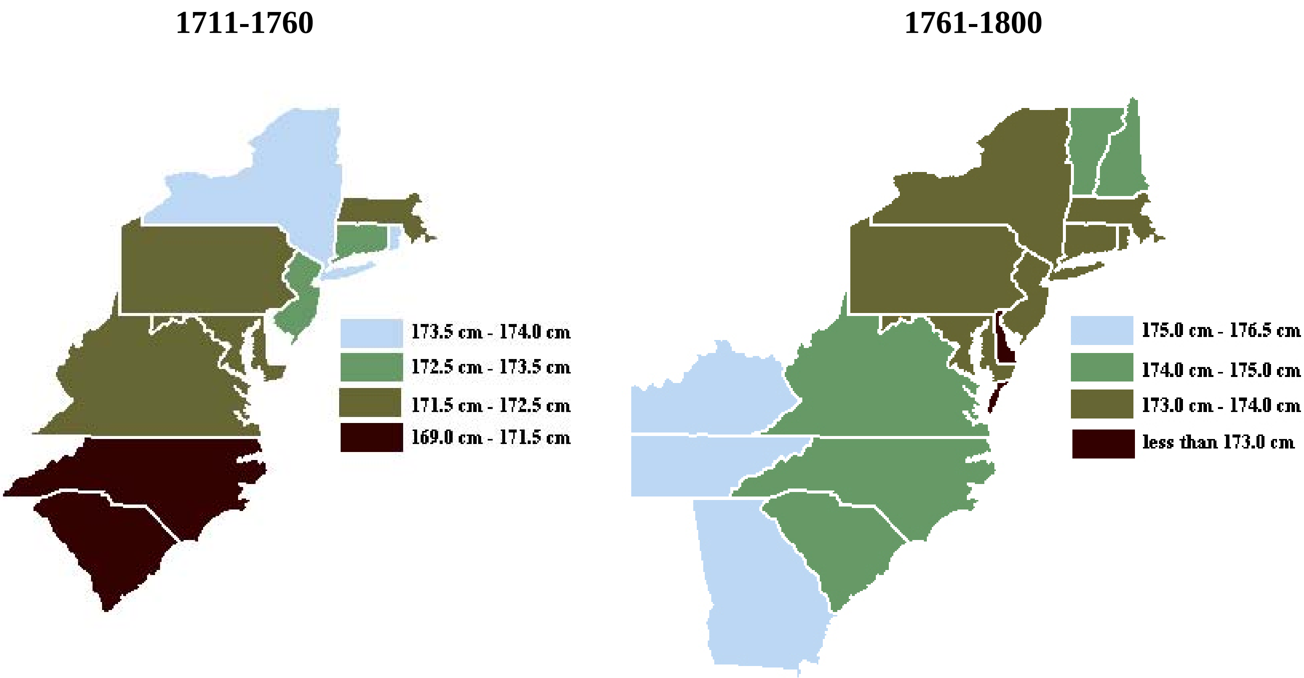
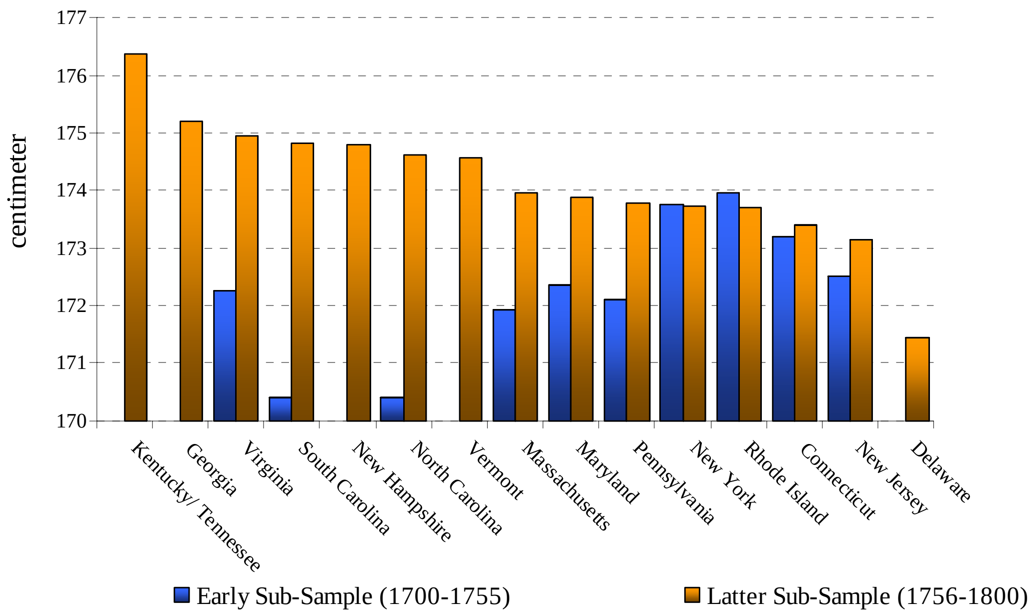
[20] We refrain from estimating separate trends in the stature over the century for the different regions, as the number of observations for each region is too small to allow for a reliable estimate.

Figure 1.7: Regional Differences in Stature



Source: Table 1.2

Figure 1.8: Height by State of Birth



Source: Table 1.2

During the second half of the century, the North-South gradient reversed. Soldiers born close to the frontier, in Kentucky and Tennessee were tallest at 176.4 cm; the southern colonies/ states followed with a range from 175.2 cm in Georgia to 174.6 in North Carolina. The non-coastal parts of New England – New Hampshire (174.8 cm) and Vermont (174.6 cm) – enjoy height levels more similar to Southerners. The remaining New England as well as the Mid-Atlantic colonies all range within 173.0 to 174.0. The smallest soldiers came from Delaware with 171.4 cm. The North-South gradient was replaced by a pattern that can best be put into words by 'the more remote, the taller'. States with a high share of coastal regions, more towns and ports and a longer history of settlement provided a less favorable environment compared to the remote regions of the frontier and the South.

These results differ to some extent from the previous studies on heights in colonial British America by Sokoloff and Villaflor (1982).[21] In their analysis of French and Indian War recruit records, Sokoloff and Villaflor find subjects from New York and New Jersey to be tallest at 174.2 cm, with a height premium of about 0.5 cm compared to New Englanders. The difference is very similar in magnitude to our estimate of 0.52 for the difference between New Englanders[22] and soldiers born in the Mid-Atlantic colonies (see model 5a). We also estimate a similar level of absolute height for Virginians: Sokoloff and Villaflor rank them second with 173.0 cm; our estimate is 0.8 cm smaller. The key difference between the results pertains to Carolinians: While the present results indicate clearly a disadvantage in nutritional status, Sokoloff and Villaflor's estimates do not exhibit a North-South gradient. Carolinians are estimated to be taller than New Englanders, even though the coefficient is not statistically significant. But as in our data, the

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[21] When discussing the spatial results obtained by Sokoloff and Villaflor, one has to keep in mind that hey use New England as reference group, while the descriptive statistics show that in the French and Indian War recruit sample not a single subject was recruited in New England. Hence, all those born in New England migrated to another state, and were hence coded as "Native-born migrants across states". Thus, the proper coefficient for comparison is not 0, as it would be normal for the reference group, but the "Native-born migrants across states" coefficient, as all soldiers born in New England were migrants. The same situation refers to Carolinians.

[22] Including the premium for migrants.

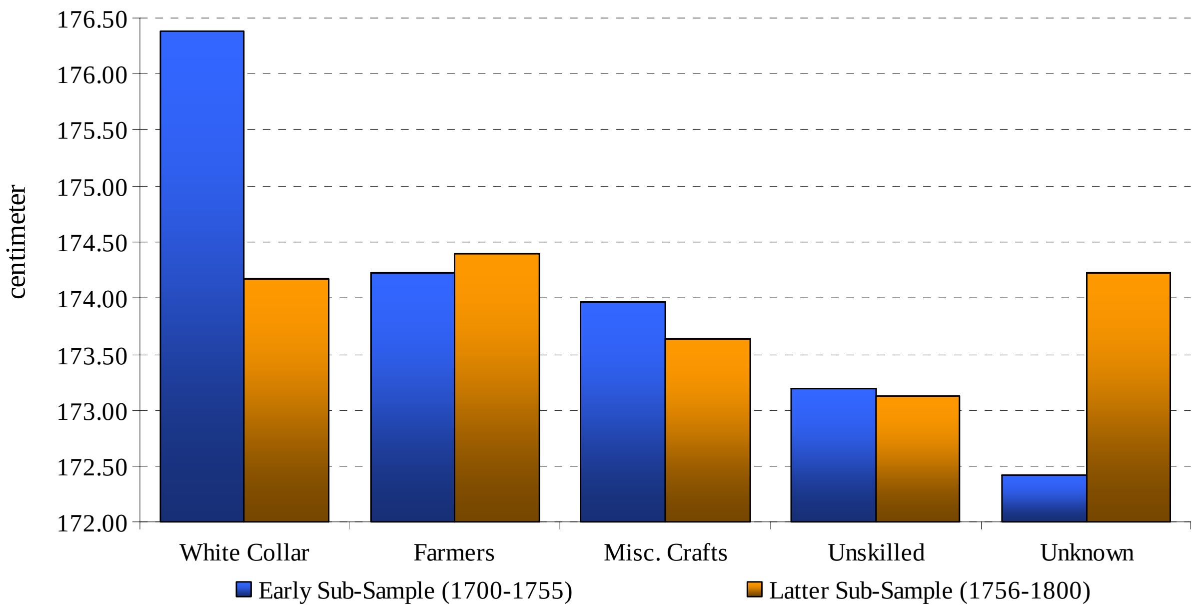
number of soldiers from the Carolinas in Sokoloff and Villaflor's dataset is very small, so this difference should not be given too much attention.

When turning to the U.S. Army records – which are the best comparable to our latter sample – Sokoloff and Villaflor find a similar regional pattern as we do, but the overall level in height is smaller. As Sokoloff and Villaflor include foreign born subjects in their analysis, their results are problematic when being compared to our analysis of native born soldiers only; but the general region ranking is confirmed.

As we only have a very small number of urban-born observations in the early part of the sample (N=4), an assessment of urban-rural difference in nutritional status during the first half of the 18th century is not possible with the data at hand. The disadvantage of urban citizens during the second half of the century is clear and significant at a level of 2.4 cm to 2.6 cm. The level of the difference is higher than Sokoloff and Villaflor's (1982) estimate for Revolutionary War soldiers, and also exceeds their estimated penalty of 1.25 cm for early U.S. Army recruits born during the late 18th century. Komlos' (2001) estimate of a 1.7 cm premium for rural born soldiers is closer to our results. Our strict limitation to only the major (and hence most urbanized) cities should not lead to an excessive level of difference, as our "rural" sample also includes soldiers born in smaller towns which should decrease the estimated level compared to a truly rural population.

It is also notable that socio-economic differences are quite small: Unskilled workers are about 0.5 cm to 0.7 cm shorter than craftsmen, and the effect is fairly constant throughout the entire period. White collar professionals seem to have been taller than craftsmen in the early sub-

Figure 1.9: Height by Socio-Economic Status



Source: Table 1.2

sample. The advantage diminishes in the latter subset, but the estimated coefficient is insignificant in all specifications and subset. Farmers, who had the best access to nutrition, enjoy an advantage of about 0.2 cm to 0.8 cm over craftsmen. The effect is small (and insignificant) in the subset born earlier in the century, but larger in the latter subset. In comparison, Cinnirella (2006) finds a height premium of 1.73 cm for Saxons working in the agriculture compared to miscellaneous craftsmen throughout the 18th century. Our results show that the biological well-being in the colonial society was quite egalitarian, a notion that was also observed with respect to the material standard of living (Perkins 1980, Williamson and Lindert 1981, McCusker and Menard 1985).[23]

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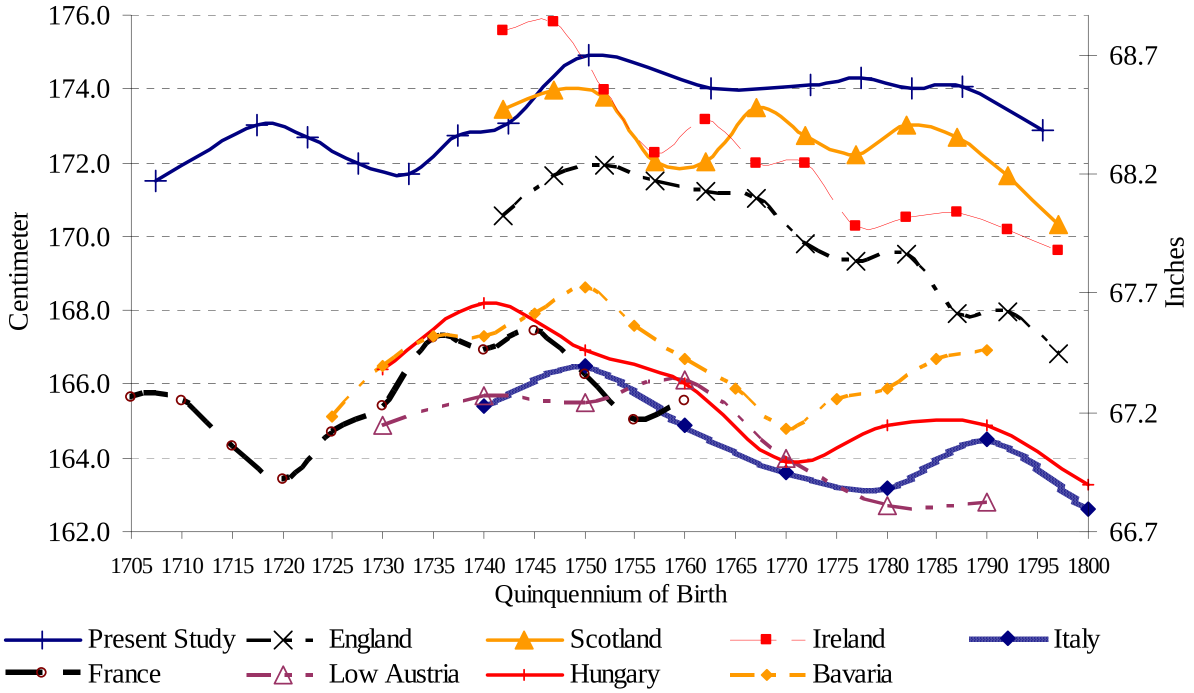
[23] Early forms of poor relief existed in the British Colonies (and subsequently, the United States). Furthermore, the common practice of bounding out the children of those not able to support their kin as indentured servants likely improved the nutritional status of the children of the poorest. See Herndon (2001) for a collection of narrative description on Rhode Island men and women living on the margin during the 18th century.

While soldiers born in the New World reached a considerably higher level of stature than European soldiers did, the trend experienced by populations on both sides of the Atlantic Ocean exhibits similarities. European heights, in the main, increased during the latter part of the first half of the century, reaching a maximum sometime between 1740 and 1760. A substantial decline followed, with a trough after 1770. The decrease was much larger than the downturn that American born subjects experienced, ranging from 3 cm in Bohemia to 5 cm in

Figure 1.10: Heights in North America and Europe, 18th Century



Source: Table 1.2, England, Scotland and Ireland: Cinnirella (2007), Italy: A'Hearn (2003), France: Komlos (2003), Austria and Hungary: Komlos (1989), Bavaria: Baten (1999)

Hungary, and England and even 6 cm in Ireland. Scottish, Austrian, French, Italian and Bavarian soldiers' heights lost around 4 cm. On the contrary, the decline in American heights was a mere 2 cm. In fact, for most of the period during which the European heights declined – 1760 to 1790 – heights in colonial British America and the United States did not decline at all.

The population on the North American continent was apparently not faced by nutritional shortages that led to the decline in European heights. The economic upswing in European economies was triggered by a rapid growth of population, and for the first time, the fundamental change brought about by the industrial revolution (allowing to trade industrial products for food on rather favorable terms of trade) lifted the Malthusian food constraint on population growth (Komlos 1989). In many European countries, starvation was, in essence, replaced by survival at the cost of decreases in stature. In North America, however, land was so abundantly available that not even modest onsets of a Malthusian threat appeared and agricultural activity could easily be expanded without having to revert to less fertile land. Nutritional status did – in comparison to the European experience – hardly decline at all.

Alternative Regression Methods

As previously discussed, two of the recruitment groups (recruitment group 2, 1776 – 1783 and recruitment group 3, 1800 – 1816) might be affected by shortfall due to minimum height requirements of the military and subsequent truncation of the dataset. Since the inspection of the histograms does not provide a clear cut answer whether the dataset is impaired or not, we add an analysis of the data using Truncated Maximum Likelihood Estimation (TMLE) – both unconstrained and constrained (Restricted Truncated Maximum Likelihood Estimation - RTMLE) to a standard deviation of 2.7 inches, which is considered to be typical for height distributions (A'Hearn 2004) – and compare the estimates to the results from our OLS regression.

Placing the truncation point correctly for the TMLE is crucial for obtaining correct results. Especially in the presence of heaped data in which the extent of heaping is different for whole, half and quarter units of measurement (inches, in our case), the proper truncation point will depend on the percentage of heaping on each of the potential outcomes. A simulation was run using the proportions from the data at hand to determine that the optimal truncation point is 0.4 inches below the last unimpaired height level (see appendix III for details) – that is, at 63.6 inches for recruitment group 2 and at 65.6 inches for recruitment group 3.

As the truncation affects those recruited after 1770 only, there is only a small number of observations affected that were born during the first half of the century (190 subjects recruited during the Revolutionary War were born in colonial America before 1755). We thus expect only a minor impact of truncation due to minimum height requirements among the earlier birth cohorts and more of a difference in time trend with respect to those born after 1755. The key finding, shown in Table 1.3 and Figure 1.11, is that while there are some changes introduced by using TMLE and RTMLE estimation, the pattern whether the TMLE estimate is higher or lower than the OLS estimate varies, and the RTMLE estimate is constantly higher than the OLS estimate. If the sample indeed suffered from shortfall, we would expect the OLS estimate to overstate the stature, not to understate it. Even though the TMLE estimate for the later subset mostly below the OLS estimate, the small magnitude of the difference and opposite result from the RTMLE leads us to the conclusion that the OLS estimates are valid and that the sample is (at least not severely, if at all) afflicted by shortfall. Hence we do not

Table 1.3: Comparison of OLS, TMLE and RTMLE Regression Results

Method	OLS	TMLE	RTMLE	Difference OLS vs. TMLE	Difference OLS vs. RTMLE
Full Sample*					
Estimated Height per Birth cohort					
1731-1735	171.75	172.04	172.02	0.29	0.27
1736-1740	173.05	173.38	173.07	0.33	0.02
1741-1745	173.86	173.70	172.97	-0.16	-0.89
1746-1755	175.61	175.17	174.96	-0.44	-0.65
1756-1770	174.53	174.31	175.39	-0.22	0.86
1771-1775	174.33	174.03	175.57	-0.30	1.24
1776-1780	174.60	174.63	175.97	0.03	1.37
1781-1785	174.30	174.25	175.72	-0.05	1.42
1786-1790	174.29	174.10	175.62	-0.19	1.33
1791-1800	173.01	173.60	175.51	0.59	2.50
Observations	12407	11000	11000		
Later Subset (b. 1760-1799)**					
Estimated Height per Birth cohort					
1756-1770	173.94	173.45	174.68	-0.49	0.74
1771-1775	173.69	173.09	174.82	-0.60	1.13
1776-1780	173.97	173.67	175.22	-0.30	1.25
1781-1785	173.66	173.29	174.96	-0.37	1.30
1786-1790	173.64	173.14	174.86	-0.50	1.22
1791-1800	172.42	172.79	174.67	0.37	2.25
Observations	8696	7293	7293		

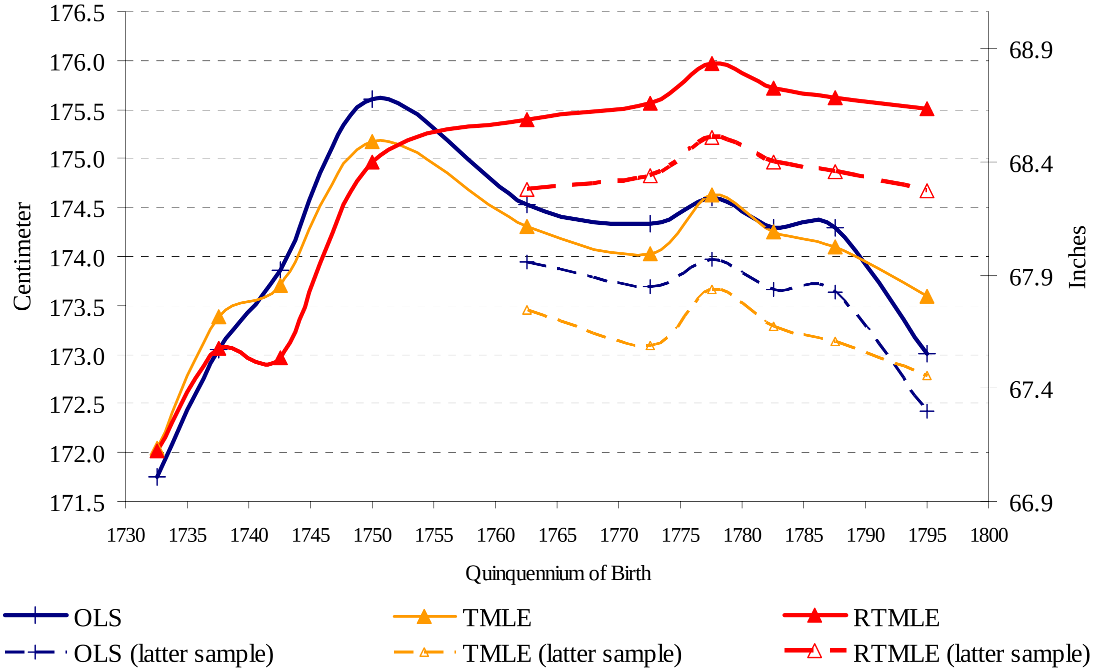
Note: All results in centimeters. 1 inch = 2.54 cm. All estimations include controls for birth cohort, age category, place of birth and profession. RTMLE constrains the Standard deviation to 6.86 cm (2.7 inches).

* Reference category is a skilled individual born between 1736 and 1740 in the state of New York, aged 22-49 years

** Reference category is a skilled individual born between 1786 and 1790 in the state of New York, aged 22-49 years

Source: Estimates based on data in appendix I, Table 1.2

Figure 1.11: Difference in the Time Trend by Estimation Method



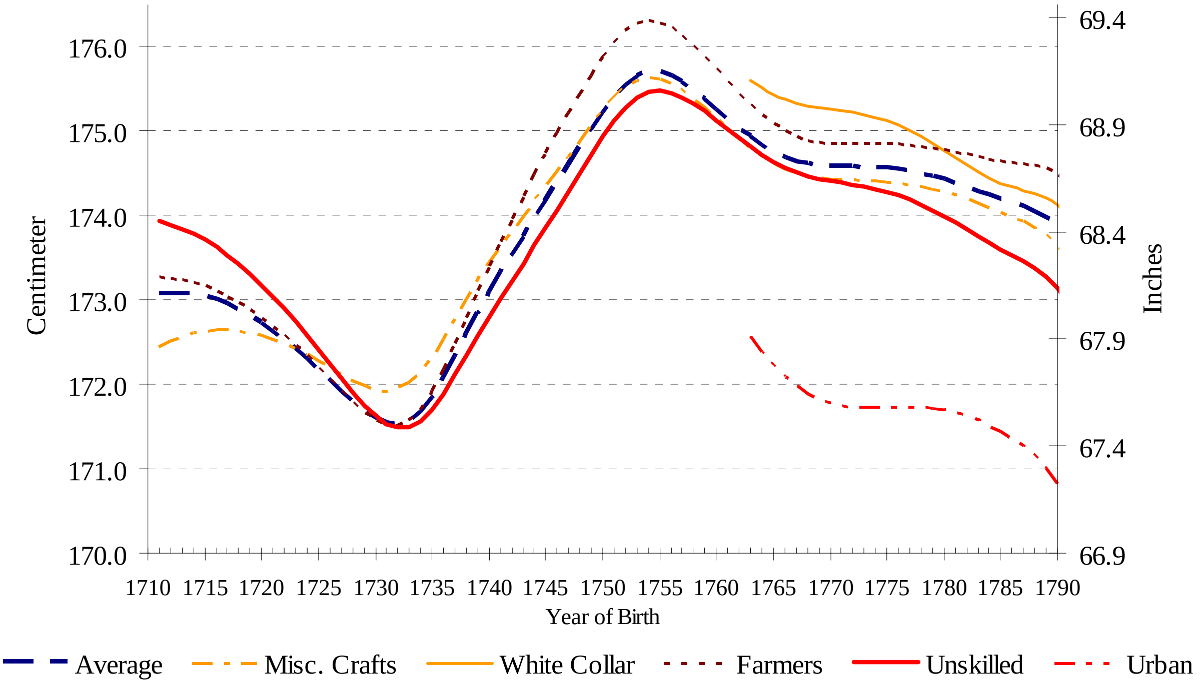
Source: Table 1.3

show the detailed list of spatial and socio-economic coefficients obtained by the TMLE and RTMLE estimations, but limit ourselves to stating that they change only marginally in all cases with a sufficient number of observations to put a reasonable amount of confidence into the OLS estimates.

We also apply Bayesian nonparametric regression procedures using the statistical package BayesX to the data. The main advantage of this procedure is that nonlinear relations of a metrical covariate can be estimated, with the effect assumed to be smooth instead of having excessive variance, as a penalization of large jumps in the estimates is implemented (see Lang and Sunder 2003 for methodological background and details).

The smoothed estimates of the time trend (Figure 1.12 for the entire dataset and Figure 1.13 limited to adults), stratified by social class and standardized to the age of 22, exhibit mostly the same properties as the OLS regression estimates. Average height decreased in the early part of the century until c. 1734 by about 2 cm for all groups. The effect was stronger for the unskilled group and less pronounced among craftsmen. Farmers followed the average closely. Afterwards, height increased for all socio-economic groups until 1755 by about 2 cm per decade. The increase was slightly stronger among farmers, while the unskilled population

Figure 1.12: Time Trend in Height – Bayesian Estimates

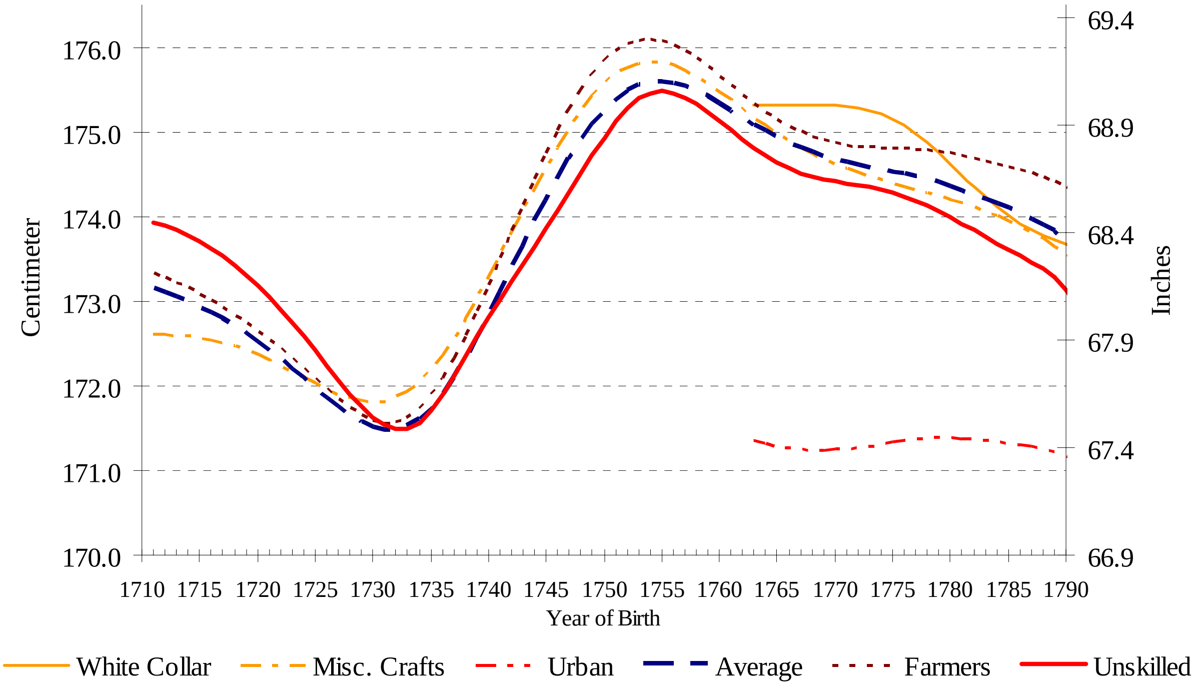


Source: Estimates based on data in appendix I
Note: Graphs show estimated adult heights after controlling for age as well as interactions of age and year of birth.

almost managed to keep up with the remainder. Following the 1755, peak average heights decreased steadily towards the end of the century to reach a level of 174.0 cm. Even though there is a short period in the 1770s where mean stature stagnated, the downward trend is not interrupted. This is a notable difference to our OLS estimate that can be attributed to the penalization of excessive fluctuation in the estimates shown in Figure 1.12.

Limiting the analysis to adults leads to the same basic pattern as the full dataset in the first half of the century and a modest but rather constant decline by about 0.7 cm per decade in the second half of the century. There are some minor differences in the trend during the second half of the century among the different socio-economic groups – craftsmen gained a little more of an advantage around the middle of the century – but the overall trend remains slightly downward.

Figure 1.13: Time Trend in Height of Adults Only – Bayesian Estimates



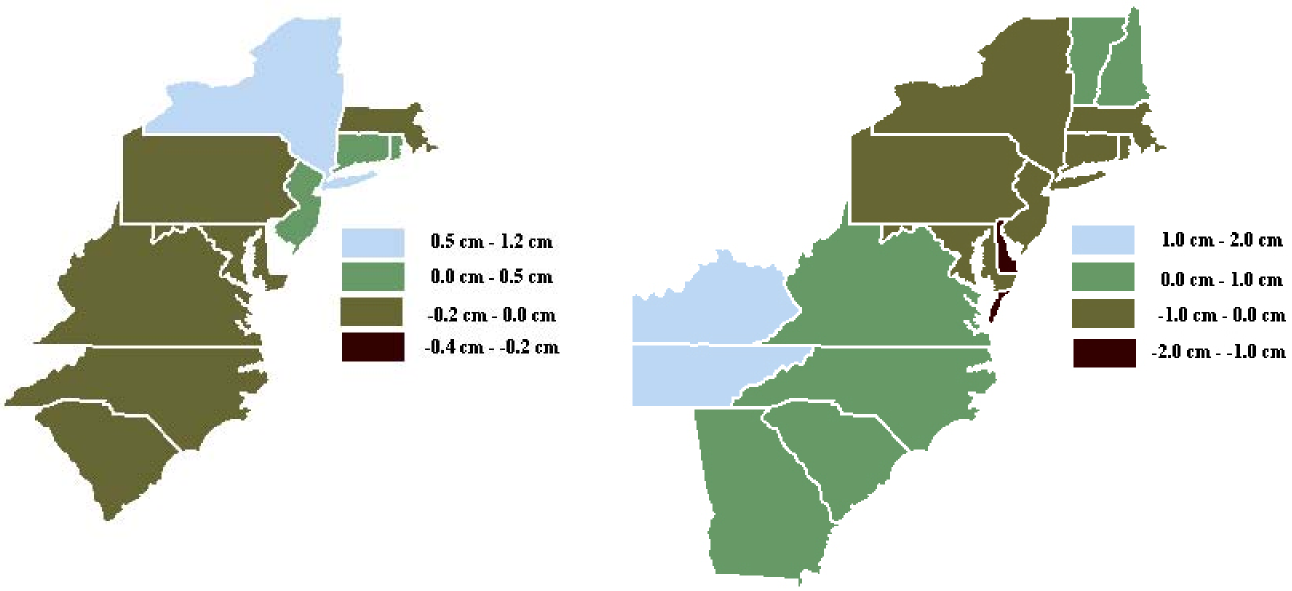
Source: Estimates based on data in appendix I

In addition to differentiating the trends by socio-economic classes, we also estimate a separate trend for being born in an urban region. As our number of observations of urban subjects born before 1765 is small, we only show the estimated trend for those born in the latter half of the century. Both the estimates for the entire native born sample as well as for the subset limited to adults show a clear disadvantage for urban born subjects. Initially in a range of 3 cm when limiting the analysis to adults, the difference decreases to about 2 cm with respect to the rural average. The difference between urban-born subjects and farmers remains greater towards the end of the century and stays near 3 cm. This convergence of the average non-farmer population to the levels of urban born subjects can well be related to the increasing level of urbanization, with numerous smaller dwellings that are not coded as urban (see above) becoming larger settlements, resembling a town more closely. This notion is supported by the increase in the advantage of farmers over non-farming workers.

The spatial results of the Bayesian estimates corroborate the pattern at hand in the OLS estimates: While Southerners were relatively short during the early part of the century, the pattern changed in the second half of the century, when remoteness from the early centers of colonial British America was associate with taller stature. Yet it is notable that the more flexible estimation approach shows relatively small and mostly insignificant differences in the early subsample of the data, and much smaller differences in the later years (Figure 1.14) compared to the OLS estimates.

Figure 1.14: Regional Differences in Stature – Bayesian Estimates

1711-1760 **1761-1800**



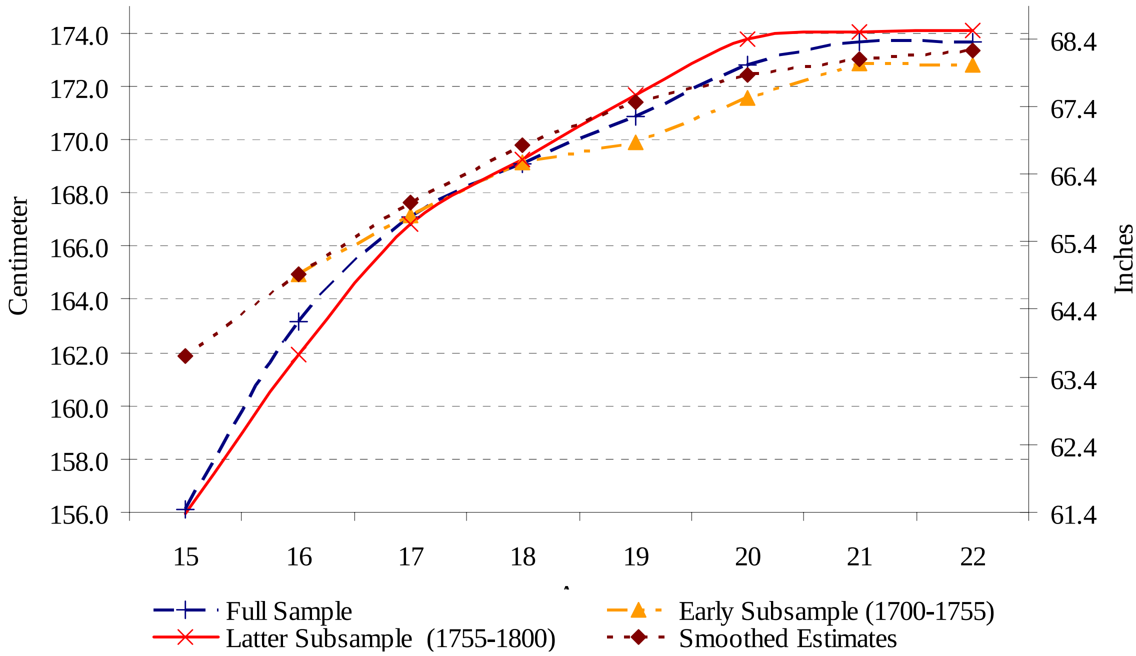
Source: Estimates based on data in appendix I

Growth Profile

While terminal height serves well for an assessment of the secular trends in the nutritional status of a population, the height at a specific age during childhood and youth of the subjects provides valuable information for the comparison to other populations. Several institutions, such as military schools, orphanages and charities, have gathered information on height of youths. The specific background and entry requirements of these institutions enable us to assign a socio-economic status to its members at a more detailed level than it is commonly possible by referring to the profession of the subject.

We plot the growth profile of youths as estimated by the OLS regression and the smoothed procedure implemented with BayesX (Figure 1.15). We only have a very small number of observations (N=3) aged 15 in the early subsample, so we omit this estimate. The latter subsample is larger (N=45) at the age of 15, and all remaining estimates ages are based on at least 90 observations.[24]

Figure 1.15: Growth Profile of Youths



Source: Table 1.2 and estimates based on data in appendix I
Note: Results are standardized to a person from the skilled class, born between 1736 and 1740 (1786 and 1790 for the late sample) in a rural area of New York.

Especially in the early sample, the attainment of tall stature during early adolescence is notable. The annual growth increments stay below 2 cm per year, and by the age of 16 (18) about 95% (98%) of the final height were reached (this is similar to Sokoloff and Villaflor's observation for their data on soldiers from the Revolutionary War that 98% of final height were attained at the age 18.3 years). As the vast majority (more than 90%) of the subjects at the age of 15 to 18 in the latter subsample experienced the effects to the War of 1812 while they were still growing, the

24 See Table 1.1 for the exact number of observations per age group in the full sample.

adverse effects of the war may have led to some stunting. While the data does not support the argument of a change in recruiting practice (a dummy variable for enlistment during the War of 1812 introduced into the regression model did not show up to be significant), the slower growth observed among the youths can probably be attributed to the negative impact of the war during the adolescent growth spurt.

Similar patterns with relatively low growth in the years past 16 have been witnessed for members of elite institutions such as the Royal Military Academy at Sandhurst, England, German and Habsburg aristocrats and West point cadet students (Komlos 2005, Komlos 2006). Evidence on lower-class subjects, such as the members of the Royal Marine Society, a charitable institution in London, shows mostly larger increments up to the age of 21. The adolescent growth spurt occurred at an earlier age among members of higher socio-economic groups than among the poor (Komlos 2005). The lower class subjects manage to reduce the difference between them and their elite counterparts only by a prolonged growth process. Hence, early attainment of final stature is a strong indicator of favorable economic conditions and good nutritional status.

The growth process of youths changed notably over the course of the century. A plot of the amount by which the respective age groups fall short of final height (measured by those aged 22 – 50 years) makes the acceleration in the growth process apparent (Figure 1.16).[25] While 18 year old boys born in the 1750s were still 5 cm shorter than adults, those born 35 years later were just 1 cm smaller than adults when they reached the age of 18. The process reverted again at the end of the century, leading to a larger delta between 18 year olds and adults. It is important to keep in mind that these estimated describe the difference between subjects born during the same period, and therefore are not affected by changes in the final level of height.

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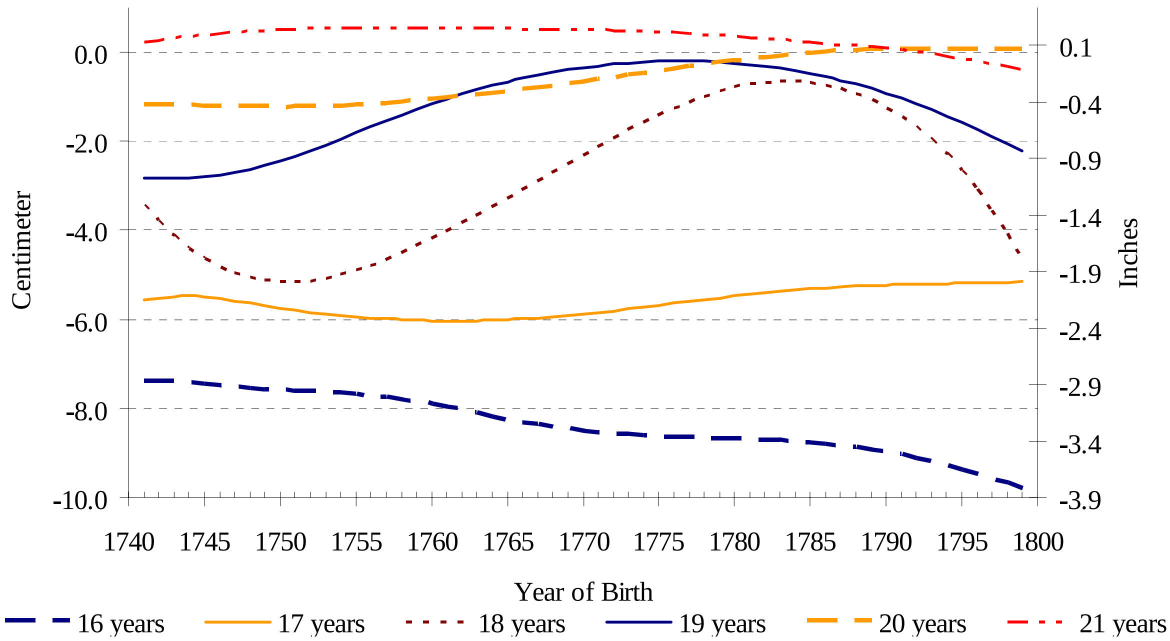
[25] The graph is based on the estimated coefficients of interaction terms between age and year of birth in the semiparametric regression setup.

Figure 1.16: Height Deficit of Youths by Year of Birth



Source: Estimates based on data in appendix I

The same pattern as described above for the 18 year olds can be seen – in smaller extents – for the group of 17 year olds, 19 year olds and 20 year olds. Referring back to the differences between Sandhurst and Marine Society boys, the change in the growth process among the American youth from 1750 to 1780 resembles a transition from a lower socio-economic status towards a higher one. This acceleration of growth is an additional piece of evidence of increasing living conditions and incomes at the beginning of the second half of the 18th century.

Conclusion

The anthropometric data utilized in this study provides valuable insights into the well-being of the population of colonial British America. Reaching back to 1710, subjects born in the New World enjoyed a significant advantage in stature over those born in Europe – around 4 cm over English soldiers (Cinnirella 2007) 7 cm over French (Komlos 2003), 6 cm over Saxons (Cinnirella 2006) and 8 to 10 cm over Austrian and Hungarian Soldiers (Komlos 1989). American heights experienced a minor downturn in the early 18th century, reaching a nadir of approximately 172.0 cm in the early 1730, only to witness a solid increase afterwards into the

1750s to an exceptionally high level of 175 cm and a modest decline afterwards, reaching a level of 174.0 cm by 1790. The overall environment in colonial British America must have been benign to support the level of stature and the increase of 2.5 cm from the beginning nadir during the 1730s to the late 1780s. The improvement in the nutritional status coincides with a decrease in the mortality levels broadly (Gemery 2000, Fogel 1986, Kunitz 1984). The onset of the increase in the late 1730s matches the beginning of a period of an economic growth spurt that lasted to the Revolution (McCusker and Menard 1985). Our estimates also show a modest downswing (or stagnation, at the maximum) in the biological standard of living for the period of the recession that accompanied the Revolutionary War. The extent of the downturn during the last quinquennium remains questionable, as the subjects born during those years might have suffered from the adverse effects of the War of 1812 before they could finish their adolescent growth spurt, and hence might have caught up to 18th century levels at a later time – the increase in the extent by which soldiers born fell short of adult height when they were 18 or 19 years old suggest a delay in the growth spurt, making the OLS estimates problematic, as they implicitly assume a constant deficit for each age cohort.

The differences in stature between colonies also exhibit a noteworthy pattern that is closely related to the changes in mortality: While Southerners were shorter at the beginning of the century, they overtook their northern counterparts and achieved a higher level of stature in the second half. As Gemery (2000) suggests, “apparently the movement inland, away from tidal lowlands, served to moderate the effects of malaria on the populace”. The South experienced high levels of mortality throughout the 17th century, and subsequent to the drop to northern levels at the beginning of the 18th century, physical stature began to catch up to its genetic potential. Especially the spatial pattern during the second half of the 18th century shows the biological advantages that a life on the frontier brought along. Those who were born to the West of the original 13 colonies, but also at the northern and southern end – pushing the colonization into Georgia and inland New England – enjoyed a considerably higher stature. The propitious impact of low population density is in turn reinforced by the height premium of more than 2.0 cm the rural population enjoyed during the second half of the century over urban born subjects.

The magnitude of the urban born deficit becomes more apparent if one considers the impact of socio-economic status: Farmers, supposedly the group with the best access to nutrition possible, enjoyed an advantage of just 0.6 cm over skilled workers, who in turn were 0.5 cm to 0.7 cm taller than unskilled workers during the second half of the century. In other terms, the impact of being born in one of the few urbanized places put a subject worse off (in biological terms) than a demotion throughout the entire range of the socio-economic spectrum. In England, at the end of the 18th century, students from the elite military school Sandhurst, enjoyed a height premium of more than 15.0 cm over poors in of the Marine Society (Komlos 2005). Such levels of inequality were unknown in the British colonies of North America.

The overall pattern of increasing heights provides some evidence for improving living standards and economic growth. While the basic pattern of improvement provides support for the view of McCusker (2000), it is able to reconcile the McCusker's view with the growth stasis theory put forth by Mancall and Weiss (1999). While there was some increase in height in the first half of the century, implying a concomitant increase in nutritional status, heights stagnated, or even declined during the second half of the century, supporting to some degree the Mancall and Weiss view. Using height data we are able to describe more accurately the cyclical nature of the colonial and early-national economy, than with other extant data.

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Williamson, J. G. and P. H. Lindert (1981) Long-term trends in American wealth inequality, in: J. D. Smith (ed.), Modeling the Distribution and Intergenerational Transmission of Wealth. Chicago: University of Chicago Press, pp. 9–94

Appendix I: List of Source Documents of the Data Used in the Present Study

A List of Captain William Cock's Rangers, Oct 21, 1755.
A List of Men out of Northampton County enlisted the 24th May 1756.
A List of Men out of Westmoreland County enlisted the 25th May 1760.
A List of Soldiers Enlisted in his Majesty's Service for the County of Prince George, May 1758.
A Muster Roll (Size Roll) of Captain Robert Stewart's Company in the Virginia Regiment, Aug 1, 1757.
A return of the 2d Company of Rangers commanded by Captain John Ashby, Oct 21, 1755.
A Size Roll of Captain Rob Spotwood's Company, Fort Young, Oct. 7, 1757.
A Size Roll of Captain Robert McKenzie's Company, 1757-1758.
A Size Roll of Colonel Washington's Company, Aug 28, 1757.
A Size Roll of Major Andrew Lewis' Company, 1757-1758.
A Size Roll of the Men Recruited from Northumberland, July-Aug 1757.
Annual Report of the State Historian, 1760.
Connecticut Officers and Soldiers, 1700s-1800s: Lists of Men in the Revolution. Vol. I, Continental Regiments, 1776
Connecticut Officers and Soldiers, 1700s-1800s: Lists of Men in the Revolution. Vol. I, Connecticut Line, 1781-1783
Connecticut Officers and Soldiers, 1700s-1800s: Lists of Men in the Revolution. Vol. II, Naval Records
Enlistment Roll of Recruits by Major Josiah Smith, Norfork, May 17, 1756.
Gloucester County Recruits by Jas Wiatt, Jul-Aug 1757.
King and Queen County Recruits, [July-Aug 1757].
Lancaster County Recruits, [July-Aug 1757].
Letter, Recruitment List, by Major Juno Willoughby, Men out of Norfolk County, Enlisted 19 May 1756.
List of Wil:msburgh Recruits, [July-Aug 1757].
Maryland Settlers and Soldiers, 1700s-1800s: Muster Rolls & Other Records of Service. Flying Camp Papers
Middlesex County Recruits, [July-Aug 1757].
Muster Roll, Captain David Bell's Company, Maidstone, May 12, 1756.
Muster Roll, Troop of Light House, Commanded by Captain Robert Stewart, Maidstone, May 11, 1756.
New York in the Revolution and the War of 1812: New York in the Revolution. The New York Line on the Continental Army.
New York in the Revolution and the War of 1812: Refugees from Long Island to Connecticut, 1776. Appendix G.
New York in the Revolution and the War of 1812: New York Colonial Muster Rolls. Volume I, Annual Report of the State Historian.
Recruits received from James City Militia, [July-Aug 1757].
Register of Enlistments in the U.S. Army, 1798-1914. Nation Archives and Records Administration, Record Group 094, Microfilm ID M233. Family History Library of the Church of Jesus Christ of Latter-Day Saints, Salt Lake City, ID number 0350307 - 0350312.
Roll of Captain Henry Harrison's Company, Jul 13, 1756.
Roll of Captain Robert Stewart's Troop of Light Horse, Jul 30, 1756.
Size Roll of Capt David Bell's Company, July 13, 1756.
Size Roll of Capt Thomas Cocke's Company, Jul 13, 1756.
Size Roll of Capt William Bronaugh's Company, Jul 13, 1756.
Size Roll of Captain Woodward's Company, Sept 24, 1757.
Size Roll of Captain Charles Lewis' Company, Jul 13, 1756.
Size Roll of Captain Christopher Gist's Company, Jul 13, 1756.
Size Roll of Captain Harry Woodward's Company, Jul 13, 1756.
Size Roll of Captain Joshua Lewis's Company, Jul 13, 1756.
Size Roll of Captain Mercer's Company, Aug 2, 1756.
Size Roll of Captain Robert McKenzie's Company, Jul 13, 1756.
Size Roll of Captain Robert Spotswood's Company, Jul 13, 1756.
Size Roll of Captain T. Waggener's Company, at Fort Holland, on ye South Branch, Aug 1757.
Size Roll of Captain Thomas Waggener's Company, Sept 19, 1756.
Size Roll of Captain William Peachy's Company, Jul 13, 1756.
Size Roll of Colonel Washington's Company, Aug 1, 1756.
Size Roll of Lieut. Colonel Stephen's Company, Jul 13, 1756.
Size Roll of the Seventh Company of the Virginia Regiment commanded by Captain Joshua Lewis, July 1757.
Virginia Colonial Records, 1600s-1700s: Virginians and Colonial Soldiers, French and Indian War, 1754-1763.
Virginia in the Revolution and War of 1812: Virginia Military Records. Appendix: Statewide and Miscellaneous Records.

Appendix II: Full OLS Regression Results

Table 1.4: Full Results from OLS Estimation

Dependent Variable: Stature	Model 1	Model 2	Model 3	Model 4	Model 5	Model 5a	Model 6	Model 6a
Birth Cohort								
1700-1715	-1.59**	-1.94**	-1.87**	-2.06***	-1.98**	-2.10**		
	(0.79)	(0.79)	(0.78)	(0.79)	(0.91)	(0.90)		
1716-1720	-0.06	-0.45	-0.36	-0.59	0.20	-0.01		
	(0.75)	(0.75)	(0.75)	(0.75)	(0.79)	(0.80)		
1721-1725	-0.38	-0.75	-0.69	-0.90	-0.08	-0.39		
	(0.65)	(0.65)	(0.64)	(0.65)	(0.70)	(0.70)		
1726-1730	-1.11**	-1.54***	-1.52***	-1.75***	-0.72	-1.11**		
	(0.47)	(0.49)	(0.47)	(0.49)	(0.57)	(0.56)		
1731-1735	-1.38***	-1.84***	-1.88***	-2.11***	-0.86*	-1.28***		
	(0.35)	(0.38)	(0.36)	(0.38)	(0.49)	(0.47)		
1736-1740	-0.32	-0.62*	-0.64**	-0.81**	0.07	-0.14		
	(0.31)	(0.32)	(0.31)	(0.32)	(0.35)	(0.35)		
1741-1745	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.		
1746-1755	1.82***	1.86***	1.67***	1.75***	1.90***	1.77***		
	(0.49)	(0.49)	(0.49)	(0.50)	(0.51)	(0.51)		
1756-1770	0.92**	0.97**	0.61	0.67			0.30	0.24
	(0.42)	(0.43)	(0.43)	(0.44)			(0.41)	(0.41)
1771-1775	1.02**	0.80*	0.68*	0.47			0.05	0.02
	(0.41)	(0.43)	(0.41)	(0.43)			(0.32)	(0.32)
1776-1780	1.22***	1.05***	0.96***	0.74**			0.33	0.30
	(0.35)	(0.37)	(0.36)	(0.38)			(0.25)	(0.25)
1781-1785	0.91***	0.73**	0.66*	0.44			0.02	0.01
	(0.35)	(0.37)	(0.35)	(0.37)			(0.24)	(0.24)
1786-1790	0.96***	0.73**	0.69**	0.43			Ref.	Ref.
	(0.32)	(0.34)	(0.32)	(0.34)				
1791-1800	-0.18	-0.55*	-0.51*	-0.85***			-1.22***	-1.20***
	(0.26)	(0.29)	(0.27)	(0.29)			(0.24)	(0.24)
Subject's Age								
15 years	-17.43***	-17.53***	-17.50***	-17.54***	0.00		-18.17***	-18.09***
	(1.46)	(1.43)	(1.43)	(1.43)	(0.00)		(1.43)	(1.43)
16 years	-10.27***	-10.52***	-10.34***	-10.50***	-7.84***		Ref.	Ref.
	(0.55)	(0.55)	(0.55)	(0.55)	(0.72)			
17 years	-6.36***	-6.47***	-6.49***	-6.56***	-5.62***		-7.32***	-7.26***
	(0.39)	(0.39)	(0.39)	(0.39)	(0.53)		(0.59)	(0.59)
18 years	-4.34***	-4.50***	-4.49***	-4.57***	-3.64***		-4.87***	-4.83***
	(0.29)	(0.29)	(0.29)	(0.29)	(0.48)		(0.36)	(0.36)
19 years	-2.61***	-2.75***	-2.76***	-2.81***	-2.90***	-3.08***	-2.45***	-2.46***
	(0.29)	(0.29)	(0.29)	(0.29)	(0.47)	(0.47)	(0.37)	(0.37)
20 years	-0.64**	-0.81***	-0.79***	-0.85***	-1.25***	-1.39***	-0.34	-0.29
	(0.27)	(0.27)	(0.27)	(0.27)	(0.44)	(0.44)	(0.33)	(0.33)
21 years	0.10	0.02	0.03	-0.01	0.07	0.01	-0.06	-0.04
	(0.22)	(0.22)	(0.22)	(0.22)	(0.39)	(0.39)	(0.27)	(0.27)
22 - 49 years	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
over 50 years	-1.20	-1.28	-1.15	-1.35	1.06	1.30	-2.44**	-2.31**
	(0.96)	(0.95)	(0.97)	(0.96)	(2.04)	(1.98)	(1.04)	(1.07)
Subject's Birthplace								
CT		-0.49**		-0.55**	-0.55		-0.33	
		(0.25)		(0.25)	(0.42)		(0.31)	
DE		-2.93***		-2.83***			-2.28***	
		(0.67)		(0.67)			(0.69)	
GA		1.27		1.04			1.49*	
		(0.86)		(0.86)			(0.85)	
KY / TN		2.19***		2.09***			2.65***	
		(0.62)		(0.62)			(0.63)	

MA		-0.27		-0.33	-1.84***		0.25	
		(0.23)		(0.23)	(0.67)		(0.26)	
MD		-0.45		-0.53*	-1.40***		0.16	
		(0.28)		(0.28)	(0.53)		(0.35)	
NC		0.55*		0.39			0.89***	
		(0.31)		(0.31)			(0.33)	
New England - unspecified		-1.11**		-1.03*	-1.76***			
		(0.55)		(0.55)	(0.56)			
NH		0.70**		0.53*			1.09***	
		(0.30)		(0.31)			(0.33)	
NJ		-1.06***		-1.02***	-1.24**		-0.58*	
		(0.29)		(0.29)	(0.58)		(0.35)	
NY		Ref.		Ref.	Ref.		Ref.	
PA		-0.57**		-0.55**	-1.65***		0.07	
		(0.25)		(0.24)	(0.46)		(0.29)	
RI		0.03		0.04	0.20		-0.02	
		(0.50)		(0.50)	(0.75)		(0.65)	
SC (incl. NC in Model 5)		0.62		0.46	-3.35**		1.10**	
		(0.42)		(0.42)	(1.31)		(0.44)	
VA		0.29		0.10	-1.51***		1.24***	
		(0.22)		(0.22)	(0.36)		(0.29)	
VT		0.56		0.30	0.00		0.85*	
		(0.48)		(0.48)	0.00		(0.49)	
not specified		-1.23***		-1.21***	-1.82***		0.18	
		(0.34)		(0.34)	(0.38)		(0.91)	
Subject's Region of Birth								
New England						-0.52*		0.42**
						(0.31)		(0.17)
Mid-Atlantic						Ref.		Ref.
South						-0.90***		
						(0.31)		
Upper South								1.33***
								(0.20)
Lower South								1.26***
								(0.38)
Unknown						-1.42***		0.32
						(0.36)		(0.89)
Urban - Rural								
Rural		Ref.	Ref.	Ref.			Ref.	Ref.
Urban		-2.81***	-2.90***	-2.74***			-2.60***	-2.43***
		(0.33)	(0.32)	(0.33)			(0.33)	(0.32)
Subject's Socio-economic class								
White Collar			0.74	0.68	2.42	2.30	0.53	0.55
			(0.50)	(0.50)	(1.52)	(1.49)	(0.52)	(0.52)
Farmer			0.73***	0.54***	0.27	0.22	0.75***	0.80***
			(0.15)	(0.15)	(0.29)	(0.29)	(0.18)	(0.18)
Skilled			Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Unskilled			-0.49***	-0.47***	-0.76***	-0.68**	-0.51**	-0.53**
			(0.17)	(0.17)	(0.27)	(0.27)	(0.22)	(0.22)
Unknown			0.29	0.23	-1.53***	-1.98***	0.58**	0.60**
			(0.21)	(0.21)	(0.56)	(0.52)	(0.24)	(0.24)
Intercept	173.08***	173.63***	173.36***	173.86***	173.96***	173.73***	173.64***	173.49***
	(0.29)	(0.31)	(0.30)	(0.32)	(0.43)	(0.42)	(0.25)	(0.19)
Observations	12407	12407	12407	12407	3699	3700	8696	8696
Adjusted R^2	0.12	0.14	0.13	0.14	0.09	0.09	0.16	0.15
F Statistic	68.088	43.308	60.516	39.994	14.325	17.649	37.656	53.981

Note: results are given in centimeters. Robust standard errors in parentheses.

* Significant at the 10% level ** Significant at the 5% level *** Significant at the 1% level

Source: see appendix I

Apppendix III – Approximation of Optimal Truncation Point for STATA's Truncreg Function

When using Truncated Maximum Likelihood Estimation (TMLE), the proper choice of the truncation point is crucial in order to obtain correct estimates. As long as the data at hand is continuous and not affected by distortions such as heaping, the choice is rather straight-forward. Even if the data is rounded to full units, the truncation point can be placed properly in the middle between the last unbiased point and the first point of observation afflicted by shortfall, assuming that the observed heights were rounding down if closer to the lower number and rounded up if closer to the higher value.

The matter is more complicated in the presence of heaped data. As a certain percentage is measured with more detail and rounded to a fraction of an inch, there is a random chance that a person with a height of, say, 66.65 inches is rounded to either 66.75, to 66.5 or 67. All three options of rounding might have occurred. The relative number of observations that were measured in more detail will affect the point that needs to be chosen for STATA's truncreg function in order to obtain correct estimates of the mean height. In the following, we create two random distributions with different means, but the same standard deviation,[26] of height and simulate the extent of heaping as it is present in the dataset pertaining to the 18th century soldiers analyzed in this paper and subsequently determine the truncation point yielding the best results for our data.

The two random samples each contain 20,000 draws from a distribution with a mean height of 67.00 (66.3762) and a standard deviation of 2.7. This sample then was heaped according to the

[26] We use a standard deviation of 2.7 inches, which has been suggested as plausible for males (A'Hearn 2004).

observed level of reported percentages of quarter-inches, half-inches and full inches. In detail, we have 3% on both quarter-inch level (0.25 and 0.75), 19% on the half-inch level and the remainder of 75% rounded to full inches (Figure 1.17 and Figure 1.18). As next step, truncated regressions (with and without constraint of the standard deviation to 2.7 inches) were run setting the truncation point estimate to every 1/100 of an inch over the range from 62 to 65.

Figure 1.17: Generated Distribution – Mean = 67.00 inches

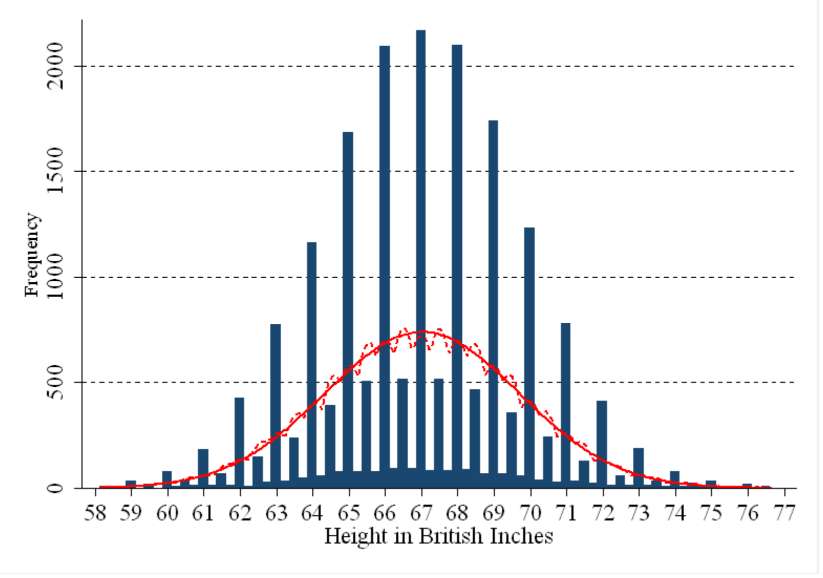


Figure 1.18: Generated Distribution – Mean = 66.386 inches

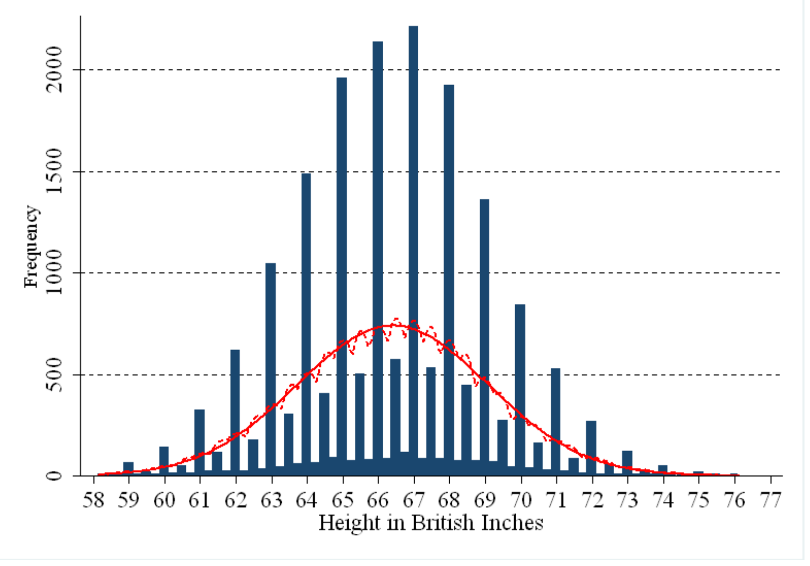
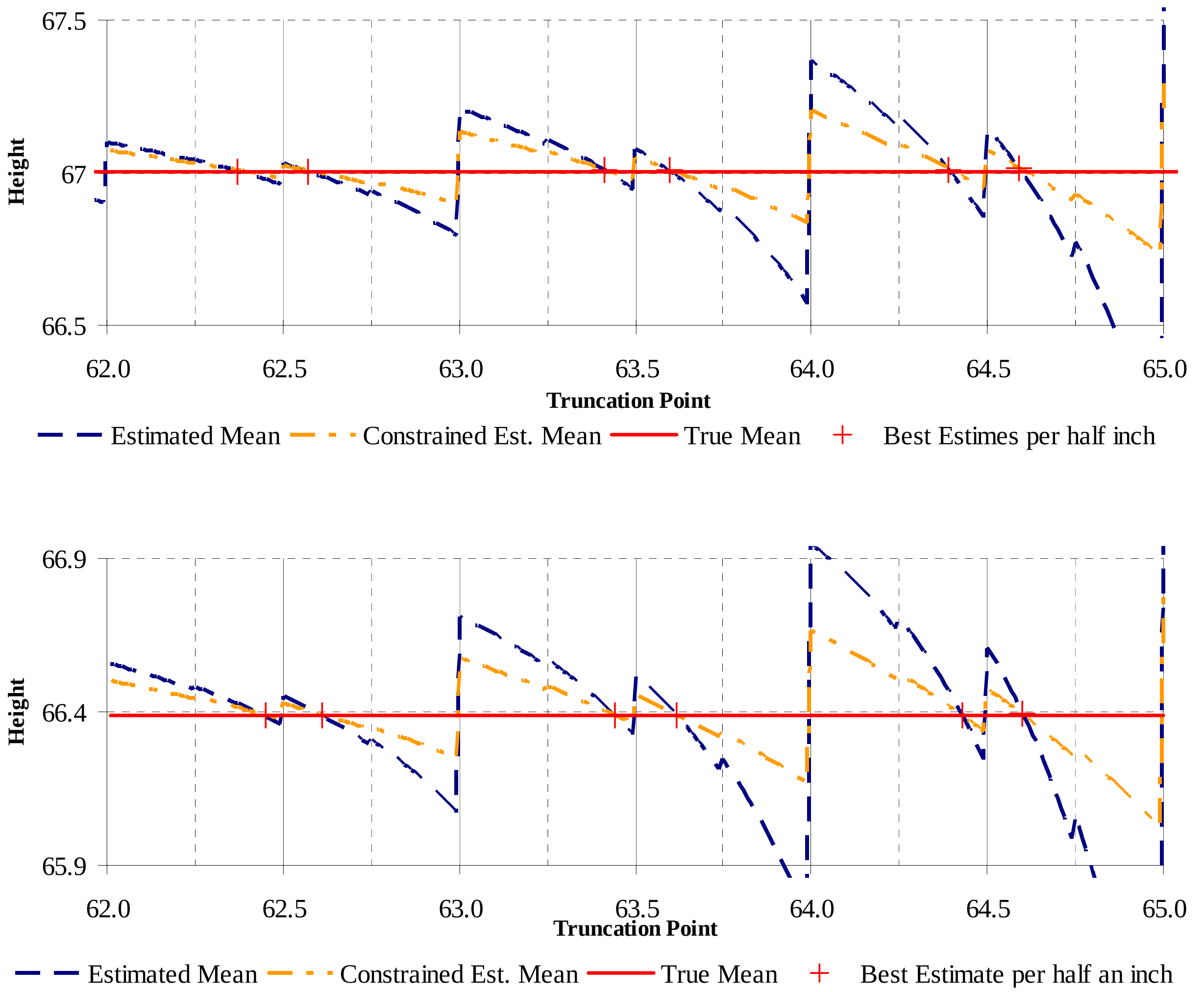


Figure 1.19 shows the estimated results using STATA's truncreg function. As expected, constraining the standard deviation to the value of 2.7 (which we know to be the true value in our sample) yields more efficient estimates than the unconstrained version. It is also apparent that the results change drastically around the values of the heaps the observations are rounded to.

Figure 1.19: Estimated Height at Different Truncation Points



Note: Upper part refers to distribution from Figure 1.17, lower part is based on distribution from Figure 1.18

Of course, the truncation point for the most efficient estimate will depend on the extent of heaping. In the setting of our data, the best estimate result from a truncation point at about 0.4 inches below the last full inch that is not affected by shortfall due to minimum height requirements. Therefore we will use 63.6 inches as truncation point for recruitment group 2 and 65.6 inches as truncation point for recruitment group 3.

PART II: On the Biological Standard of Living in Switzerland c. 1830

Abstract

Using data on the height of soldiers in the British Swiss Legion of the Crimean War, we investigate changes in the Biological Standard of Living in Switzerland between 1815 and 1840. The results indicate that heights declined among those born past 1830. Spatial effects based on canton of origin show no substantial variation. Despite several limitations of the dataset and the provisional nature of the results, the findings shed some light on the standard of living in Switzerland during the period between the Napoleonic Wars and the formation of the modern federal state.

Introduction

Anthropometric data – human height especially – is commonly used to assess the well-being of a population, both in absence of other data like GDP per capita and as supplements to more classical measures (Fogel 1994). The link between living conditions (access to nutrition, disease environment and workload) and human height is well established. The height attained can be considered as a function of the net nutritional status, that is, calorie intake net of claims on the human body by physical work and diseases, during childhood and adolescence (Cole 2003). Individuals exposed to a shortage of food during infancy and puberty will not be able to attain their genetic potential in height. Genetic differences between individuals account for a great deal of the difference in final adult height; however, on a population (or large sample) base, these differences do not affect changes in height over time (Steckel 1995). Yet, given the complex nature of the human growth process, in making inferences based on height data a multitude of factors influencing height must be taken into account. Still, data on human stature provides a very useful indicator to enhance our understanding of changes in the quality of life.

Anthropometric data are especially useful for our understanding of changes in the living standards for periods prior to the advent of widely-collected statistics. Lacking any other reliable source of data, human height serves as a preferred indicator of economic progress and living standards (Komlos and Snowdon 2005).

For the case of Switzerland, reliable statistical data on national level is scarce for the time period before the inception of the current federal state in 1848. While some data on several aspects of life exists at the cantonal or county level, no consistent data exists at the national level for first half of the 19th century. The time series data that are available – for instance, real wages and prices, but also population data – rely on estimation or are limited to small groups/ regions within Switzerland. Therefore, this paper will explores for the first time the living standards in Switzerland in the first half of the 19th century by analyzing the height of the soldiers serving in the British Swiss Legion during the Crimean War.

Switzerland during the First Half of the 19th Century

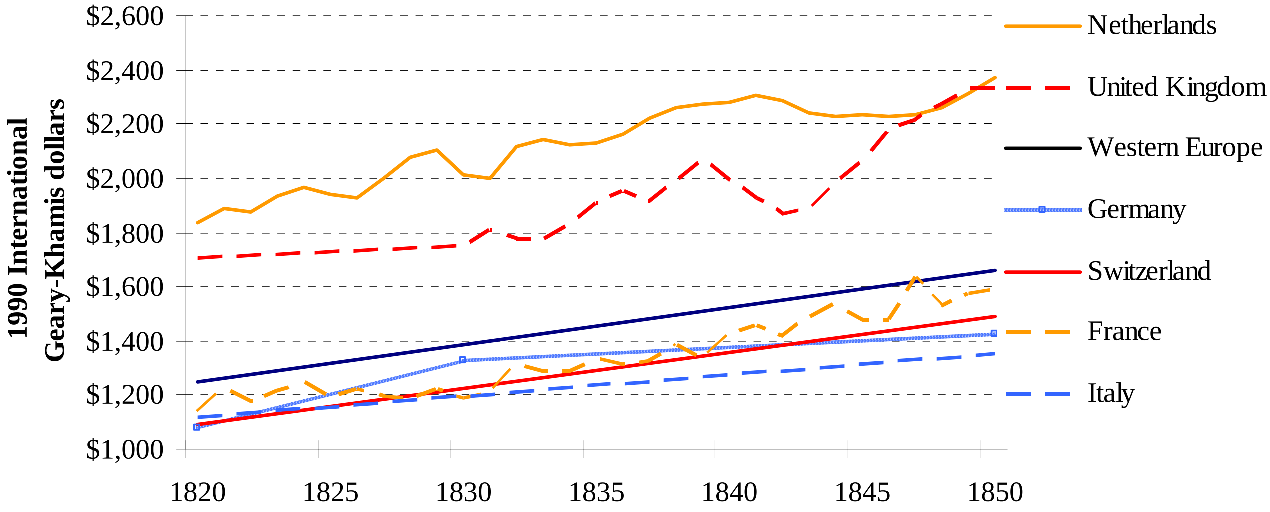
A Short Overview

After 1798 Switzerland's political structure had been shaped mostly by French influence but the Congress of Vienna restored independence in 1815. The Swiss cantons reconstructed their loose confederation in 1814/ 1815 in the "Federal Treaty", giving most of the political power to the cantons and some limited legislative and executive power to the "Tagsatzungen", meetings of delegates of the cantons. But beginning in the 1830s, public support for a modern federal state and constitution reemerged (referred to as "regeneration"). However, during the 1840s, the differences between the mostly catholic conservative and liberal cantons accumulated and by1845, the conservative cantons decided to secede to form a separate union. The consequences were a short civil war (the "Sonderbundskrieg") in 1847 that was lost by the seceding cantons and eventually the inception of modern-day Switzerland in 1848.

With respect to economic development, the Swiss cantons experienced significant changes during this period. While the production of cotton products was extensive already before the turn of the century, the Swiss industry relied mostly on home spinning of yarn, not on large scale factories. At the eve of the French revolution (prior to the advent of mechanization in textile industry), Switzerland was one of the largest producer of cotton products in the world (Wittmann 1963) and the introduction of mechanical spinning machines lead to structural changes in the Swiss economy. During the Napoleonic Wars, the continental blockade of British products allowed the Swiss production to flourish, but by 1813, when the blockade was abolished, British yarn flooded the Swiss market, forcing a large number of Swiss companies out of business. More importantly, British yarn eliminated hand-spun yarn home production completely. Those who did not manage to shift their production to weaving ended up unemployed. The technical improvements brought along by the Industrial Revolution still lead to economic growth, even though more jobs were lost than created as consequence of mechanization.

The scarcity of natural resources like coal and iron in Switzerland and the small interior market also shaped the industrial structure. Swiss entrepreneurs focused on manufacturing industries, producing high quality products for high prices instead of cheap commodities in huge numbers. Lacking other sources of energy, the factories were not placed in the cities but in the countryside along rivers, utilizing hydropower for their production. Subsequently, international trade played a great role – by 1830 the export value per capita was above the British value (Felder 1998).

Figure 2.1: Per Capita GDP, Europe 1820-1850



Source: Maddison 2003

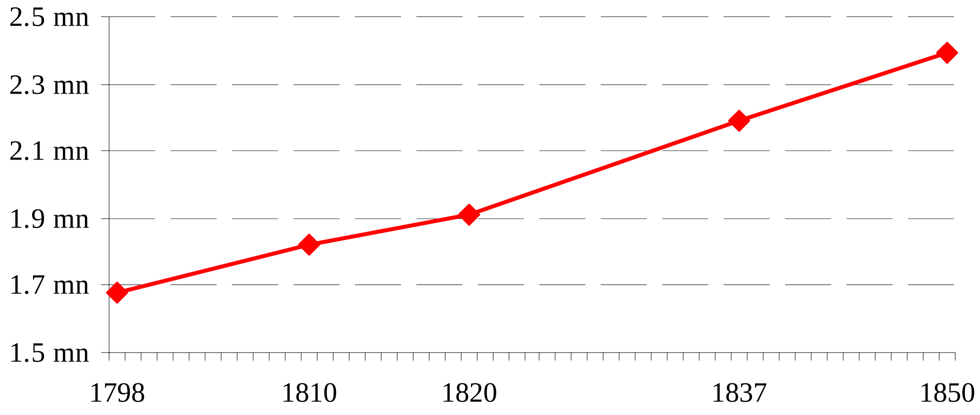
A comparison of the per capita income between 1820 and 1850 shows that Switzerland was below the western European average (Figure 2.1). The gap between Switzerland and the rest of Western Europe remained fairly stable during this time at circa 10% (Maddison 2003).

Demographics

Population Growth

Switzerland, as most European countries, experienced a sharp increase in its population in the first half of the 19th century. The population increased by 42% (or 0.7% per annum) between 1800 and 1850. This places Switzerland well within the normal European range during this period. While the British population more than doubled, the Netherlands, Germany, Belgium and Sweden experienced an increase between 44% and 48%, and Austria's, Spain's, Italy's and France's population grew by about 29% to 34% (Bickel 1947). The fastest growth took place in the region of Basle, Berne, Solothurn and Aargau in the Midlands ("Espace Mittelland"), relatively flat regions with a propitious environment for agriculture. The regional differences were substantial: population increased by about 30% in the eastern parts of Switzerland but more than 80% in the city of Basle.

Figure 2.2 Swiss Population, 1798-1850



Source: Bickel 1947

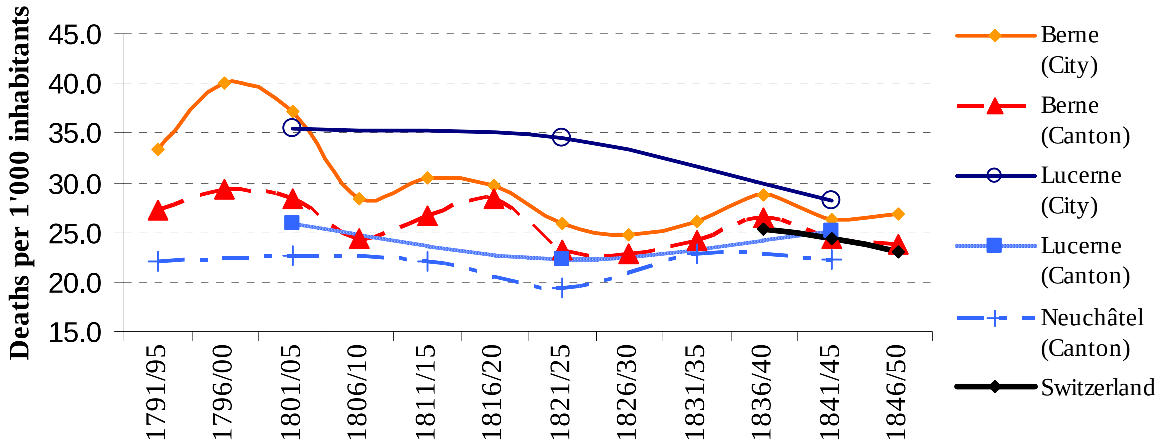
The patterns of international migration also changed: While the annual average emigration in the centuries before was between 2,700 and 3,900 emigrants per year (or 2.3 to 2.8 per 1,000 inhabitants), the annual emigration decreased to about 1,000 per year during the period from 1798 and 1837 and to 1,150 from 1837 to 1850 (Bickel 1947). The decrease can be attributed to much smaller number of military migration: Since the 16th century, between 35% and 60% of the birth surplus emigrated as mercenaries, and less than 10% emigrated as civilians (Höpflinger 1986). The rise of modern nation states led to a significant decline in the demand for mercenaries, even before the Federal constitution of 1848 outlawed this profession. The level of emigration resulted in approx. 72,500 Swiss citizens who lived abroad in 1850. This equals to about 3% of the Swiss population – a relatively low level that would increase during the years of larger-scale emigration during the second half of the 19th century (Durrer 1885).

Mortality

The rise in the absolute number of the population was also affected by average mortality rates experienced by the Swiss population. Yet the decrease in mortality implies more than a stronger population growth: It also implies an improving health situation of the respective population. Thus, when discussing the standard of living – especially from a biological perspective – mortality as an indicator of the health of the population should be taken into account. Mortality and its changes over time can foster the understanding of how the disease environment changed.

As mentioned before, statistical data for Switzerland before 1848 is somewhat scarce. While there is a fair number of records available on how many people died, the size of the underlying population is generally based on estimates. Therefore, mortality rates estimates are available for only some cantons for most of the time period in question. Figure 2.3 shows trends in mortality for three cantons, stratified by urban/ rural population if data is available.[27]

Figure 2.3: Crude Death Rates in Switzerland, 1790-1850



Source: Bickel 1947, Burri 1975, BERNHIST

Most notable is that the mortality rate in cities was considerably higher than in the countryside.[28] Explanations for this difference include insufficient sanitary conditions as well as irregular supplies of food. However, the differences between regions are also significant.

[27] For the cantons of Berne, data taken from the BERNHIST database was used to calculate quinquennial averages. For Neuchâtel, decennial averages, based on data collected by Bickel (1947), are shown. The Lucerne data represents averages over the periods from 1798 – 1816, 1816 – 1837 and 1837 – 1850.

[28] This result was obtained in earlier time periods for the City of Geneva and the surrounding canton of Vaud as well (Höpflinger 1986)

Average life expectancy in the more wealthy regions was almost twice as high as in their poorer counterparts: almost 40 years in Entlebuch, Lucerne, compared to about 21 years in Haslen, Appenzell (Höpflinger 1986). To be sure, the life expectancy was so low because only every other children reached adulthood; yet, the regional differences remain staggering.

The data can also be used as indicator for potential nutritional crises. First, at the turn of the century, the impact of the Napoleonic Wars is clearly visible. Secondly, the well-documented famine during the period from 1816 – 1820 led to another peak in mortality, especially among the rural population. The minor upswing after c.1825 may be related to an economic downturn (decreasing wages are reported for this time as well, see Figure 2.6 below) which might have been accompanied by another – yet much less adverse – food shortage. However, the contemporary literature does not mention any severe shortages for this time. Aside from these shocks, the overall downward trend in the mortality was slight and fluctuating. This suggests that biological living standards were subject to cyclical fluctuations

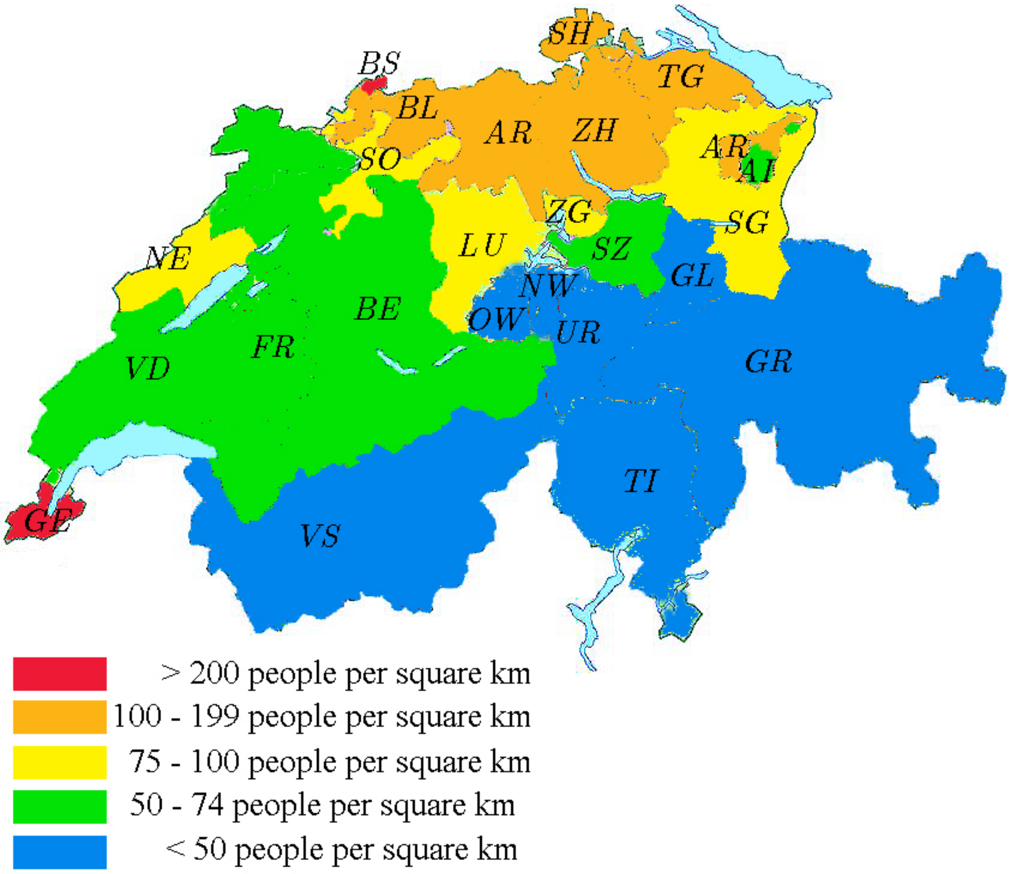
Urbanization

Low population density is favorable to human growth because of the relative abundance of nutrients and because of the infrequent contact with pathogens which in turn implies a relative abundance of nutrients (on a per capita basis) as well as a smaller incidence of endemic and epidemic diseases (Steckel and Prince 2001, Komlos 2003). Switzerland in the early 19th century had virtually no large cities: The largest settlement in 1850 was Geneva with just over 30.000 inhabitants; altogether there were just eight cities that had more than 10.000 inhabitants (Bickel 1947). Only 6% of the Swiss population lived in these cities; the vast majority of the Swiss population lived in communities with less than 2.000 inhabitants (Figure 2.4).

Figure 2.4: Population in Switzerland by Size of Settlement, Early 19th Century.

Source: Hardegger et al. 1986

Figure 2.5: Population Density by Canton in 1850, Population per Square Kilometer



Source: based on Ritzmann-Blickenstorfer 1996[29]

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[29] AG: Aargau, AI: Inner Appenzell AR: Outer Appenzell, BE: Berne, BL: Basle (rural), BS: Basle (city), FR: Fribourg, GE: Geneva, GL: Glarus, GR: Grisons, LU: Lucerne, NE: Neuchâtel, NW: Nidwald,

Since the lack of energy resources required the placement of factories along the riverside, there was no also strong tendency towards urbanization during the first half of the 19th century. The density of the population varied considerably from canton to canton (Figure 2.5).[30] Obviously, in the alpine regions the low population density was a consequence of the relatively small amount of inhabitable land. In these instances, food and nutrients may have been even scarcer than in the lower regions.

Industrialization

The beginning of modern economic growth of Switzerland can be placed in the first two decades of the 19th century (Wittmann 1963). The industrial revolution during these years is also reflected by the changes in the shares of people working in the agricultural and the industrial sector. While about quarter of the labor force worked in the industrial sector in 1800, by 1850 the share had increased to about a third. More noteworthy is the fact that while in 1800 most industrial workers (60%) still worked in home-based industry, and large-scale production facilities hardly existed, by 1850 the share of the large scale industry rose to about 12%, and home-based industry declined to approximately 48% (Kneschaurek 1960), with the remainder working as craftsmen (including construction).

Yet it is important to note that Swiss industrialization was quite different than most other countries: The contemporary economist Emminghaus (1860) noted that Switzerland had

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OW: Obwald, SG: St. Gallen, SH: Schaffhausen, SO: Solothurn, SZ: Schwyz, TG: Thurgovia, TI: Ticino, UR: Uri, VD:Vaud, VS: Valais, ZG: Zug, ZH: Zurich.

[30] To be sure, the population density varied greatly also within the cantons, especially in the larger ones such as Berne, which stretches from the Jurassic Mountains across the so-called middle land up into the Alps.

"…industrial villages, industrial valleys, industrial cantons; it is even an industrial country par excellence – but it does not have industrial cities, no Manchester, no Leeds, no Dundee or Belfast..."

Instead, most of the industrial products were produced in the rural areas around the cities and along the river valleys, while the urban business focused on trade. Laborers did not work in factories, but at home, working at piecework rates instead of hourly wages. However, even at home the living conditions were poor: The typical diet of a band weavers ("postamenter") consisted of "3-4 times coffee with potatoes or bread", with hardly any flour, rice, corn or meat or other more nutritious foods (Hardegger 1986). Hence, the most ailing and weak children could be found among this class of people.

The lack of natural resources, especially coal and iron, the spring wells of industrialization in England, the Ruhr area, Silesia and other prominent regions of industrialization, forced the Swiss to engage in light industry such as textiles. By 1840, textile products constituted 73% of the exports (Bergier 1983). Production was increasingly mechanized. In fact, about 100.000 jobs were lost within the first 12 years after the first mechanical loom was introduced in Switzerland in 1801. The mechanization led to a major deterioration in the economic situation of the rural population, who relied on home-based weaving and spinning as a source of additional income (Kneschaurek 1960).

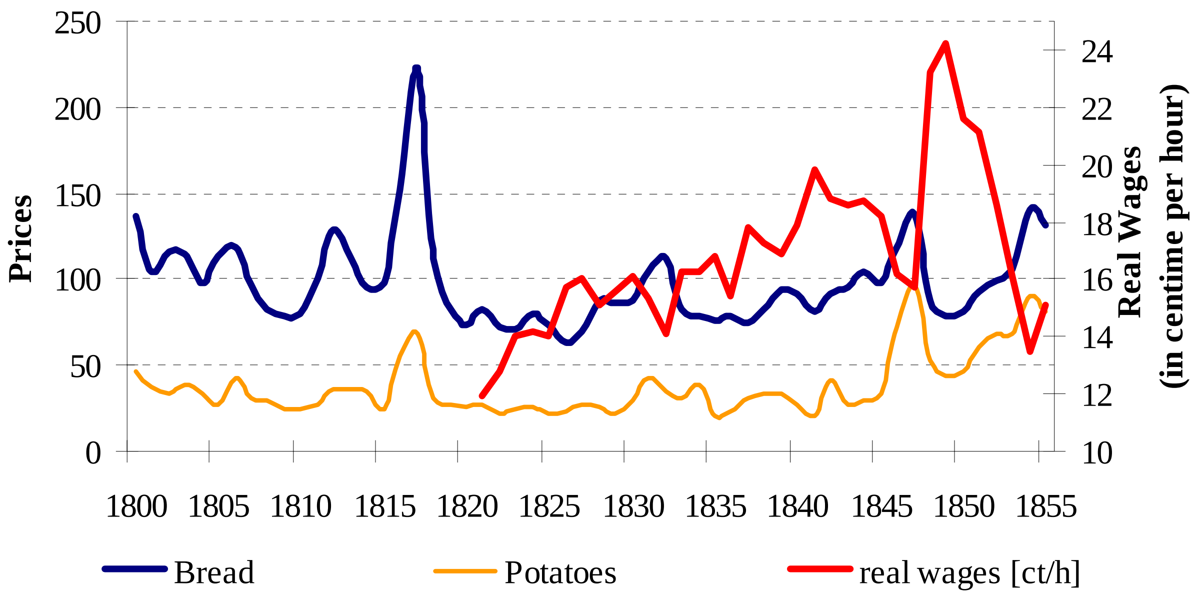
Price Level Trend

Since expenditures for food made up a major part of the budget of an average person in the 19th century, changes in the price of agricultural products (especially grain) had an impact of the general welfare of the population. However, it is important to take into account changes in the level of real income.

Real Income

Available real income is obviously an important derterminant of living standards. Especially during the industrial revolution, when the predominant occupation shifted from agricultural workers with direct access to food to industrial workers, monetary income was increasingly required to purchase one's food in the market place. In Figure 2.6, the trend of hourly real

Figure 2.6: Real Wages and Price Level Development in Switzerland, 1800-1855



Source: Ritzmann-Blickenstorfer 1996

wages is shown for the period after 1820. Prior to that, no adequate data are available. There is a clearly increasing trend in the real wages during the period in question, but in several subperiods, considerable decline can be seen, as between 1842 and 1849, and even more pronounced in the period after 1850. But despite the severe decline in the 1840s, it should be noted that the low levels of 1820 as well as the low of 1832 was not reached again prior to 1854. Thus, one would expect that those born in the second quarter of the 19th century should have been better off than those born in the 1820s for most of their childhood.

Foodstuff Prices

Foodstuff prices were influenced most importantly by the outcome of the previous harvest. Years with unfavorable harvests tended to increase the price of grains considerably, given the relatively inelastic demand for food. Yet, a poor harvest may have been beneficial for large-scale producers of grain, since the increase in the price level did more than offset the decrease in amount of output (Post 1971). However, for self-sufficient farmers as well as for industrial workers, bad harvests and the subsequent high grain prices had a great negative impact on their nutritional status. Instead of taking the separate series for the different kinds of grain into account, we focus on bread in order to take substitution effects between the different grains into account. Also, as potatoes became very popular as a crop after the devastating harvest of 1816/1817 and most workers fed on virtually nothing else (Felder 1998, Hardegger 1986), we also provide a price series for potatoes.

Most notably in Figure 2.6 is the peak in grain and bread prices in 1817 (Brugger 1956). Aside from the price peak in the late 1810s, the overall price level remained fairly stable, with greater fluctuations in the time prior to the restoration of Switzerland in 1815. After 1820, there are only two peaks: in 1845/1846, when a grain harvest that remained below average occurred simultaneously with a potato disease that ruined great parts of the harvest (NZZ 1845), and lastly during the early 1850s. A three-years series of unfavorable harvests in from 1829 to 1832 (Brugger 1954) resulted only in a modest increase in the price level.

Integration of markets also influenced the price level, as with increasing integration local fluctuations could be compensated for, but variation in the world market price would increase the local volatility of the price level. In 1855, the Federal Department of the Interior estimated the required imports of grain products at about 41 % of the annual consumption in Switzerland (Beiträge zur Statistik 1855). A comparison of the trends in grain prices in Switzerland and across Europe shows a high level of correlation between the Swiss trends and international market places (Steiger 1982). In spite of internal tariffs levied by the individual cantons as well as non-standardized measurement units and even before the advent of the railroad in Switzerland,[31] the Swiss grain market was fully integrated into the European foodstuff pricing structures by the middle of the 19th century.

Any increase in foodstuff prices led to a decrease in real wages; this points out once more to what extent the purchasing power was influenced by the costs of food. Based on the data above, nutritional shortages (if there were any) are likely to have occurred in the second half of the 1840s/ early 1850s, when the cumulative increase in grain prices since 1820 exceeded the increase in the real wages.

Contrary to grain, transportation of milk products was limited to cheese and, to a lesser extent, butter. Fresh milk could not yet be refrigerated for transportation purposes, and hence milk was mostly consumed (or fed to livestock) by farmers and their kin. Subsequently, most farmers owned only a small number of cattle (Brugger 1954). Steiger (1982) estimates a number of 909,000 head of cattle in 1850. This implies a ratio of 0.38 head of cattle per capita – a level that was similar to other European countries: France had an average ratio of 0.33, Germany 0.36 (with local variations: the respective value for Bavaria was 0.56) and the Austrian value was 0.42 (Baten 1999). Yet the productivity of the cattle in Switzerland was apparently much higher: citing evidence from numerous places and dates in Switzerland, Brugger considers an annual production of milk per cow between 1.600 and 1.700 liters as best estimate. This range is further corroborated by additional sources cited by Steiger. In contrast, the estimates for Germany cited by Baten range between 800 and 1.150 liters. Thus, the per-capita production of milk protein was apparently above European levels due to high productivity of the Swiss cattle.

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[31] The first train connection on Swiss ground was established in 1844 (Hauser 1961).

Data

Height Data on Swiss Mercenaries

The data set analyzed in this paper stems from the attestation records of the British Swiss Legion, gathered by the British War Office. The data is stored at the Public Record Office (London) Holding WO15 (War Office), Piece numbers 70-83. It includes 2,868 records of mercenaries in service of the British Empire in 1855 and 1856 during the Crimean War. The data recorded includes the height of the soldiers (measured in British inches, rounded to whole Figures) as well as an indication of the origin of the subject. Since the date of attestation is not shown for all subjects, and the data set does not provide information of the exact date of the soldiers attestation (only the respective year is given), the year of birth was computed by subtracting the age from 1856.[32] Since the dates of attestation vary from August 1855 to April 1856, this procedure should not introduce any systematic errors.

A thorough overview of the history of the British Legions in the Crimean war can be found in Bayley (1977). In levying an army to fight the Crimean War, the British War Council suffered severe difficulties while recruiting at home. Hence, the British engaged in foreign (mercenary) recruiting. By this means, three foreign legions (German, Italian and Swiss) were compiled.[33] To understand the origin of the data used here, one needs to be aware of the circumstances under which the British Swiss Legion was created – as we obviously do not have a random sample of the underlying Swiss population.

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[32] For some observations, the month of the attestation is also included.

[33] The records of the Italian Legion have been lost. The records of the German Legion are analyzed in Coppola (2006).

Shortcomings of the Data Set

Sampling Process – Selection and Self Selection

Until 1848, Switzerland had a long standing tradition in providing mercenaries to foreign powers. The Papal Guards were not the sole example of Swiss mercenaries as the ever-present oversupply of population kept up the pressure to emigrate, most frequently as soldiers. Local lords used the sale of the subjects as a frequent source of income. But following the constitution of the Swiss federal state in 1848, the federal government decided to set an end to this practice. It introduced a section in the federal constitution (Article XI) that prohibited any canton from providing armed forces to foreign powers and to engage in foreign conflicts.[34] In addition to the new limitations to the cantonal governments, the criminal code was amended in 1851 to prohibit recruiting activities for foreign service, penalizing severely persons engaged in such attempts on Swiss territory. However, the law was relatively new in 1855, and the cantonal police authorities (in the Swiss federal system designated to put the criminal code into action) were more than just negligent about this provision of the law. In fact, as it was still in the interest of several cantonal governments – especially the losers of the civil war of 1847, who still had cantonal armies in place – to "disband" these units by transferring them entirely to the British forces. Nonetheless, this clear violation of the law hindered British recruiting activities. For instance, no recruitment depots could be used on Swiss territory.

Furthermore, the British agents were not the only ones seeking to strengthen their forces with Swiss soldiers for the Crimean War. French agents were recruiting as well, and they received higher bounty than the British for each men brought into service. Since the government of Austria declined a British request to open depots at Bregenz and Feldkirch, and the Grand

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[34] This was the first step to establish Swiss neutrality in international relations.

Duchy of Baden did likewise for depots in Constance and Lörrach, the British were forced to set up their main recruitment depot in Sélestat (Schlettstadt), France, about 80 km north of Basle. Supposedly, the French recruiting agents did also attempt to divert British recruits "into French service by tempting offers as they were approaching the assembly base at Schlettstadt" (Bayley 1977). However, the extent to which such diverting really happened is unclear.

These overall circumstances indicate that the sample at hand stems probably from the bottom segments of the Swiss social distribution. People had to be rather desperate to find the British offer appealing. This implies that the level of heights observed in the sample is most likely not representative of the Swiss population; however, the trend can be assumed to be the same as the general trend of the poorer segments of the society.

Minimum Height Requirement

British army imposed a minimum height requirement (MHR) on its soldiers, as it was common practice in most armies during this time. The official minimum height was 62.0 British inches (Bayley 1977). However, these rules are rarely followed exactly, and a visual inspection of the height distribution is required to gain assurance of the true truncation point. As Figure 2.7 shows, the clear deviation from a normal distribution occurs at 62 inches, so the formal minimum height was also the effective height requirement. The figure is based in the entire sample of 2'864 observations, as the height requirement referred to Swiss and foreign soldiers alike.[35]

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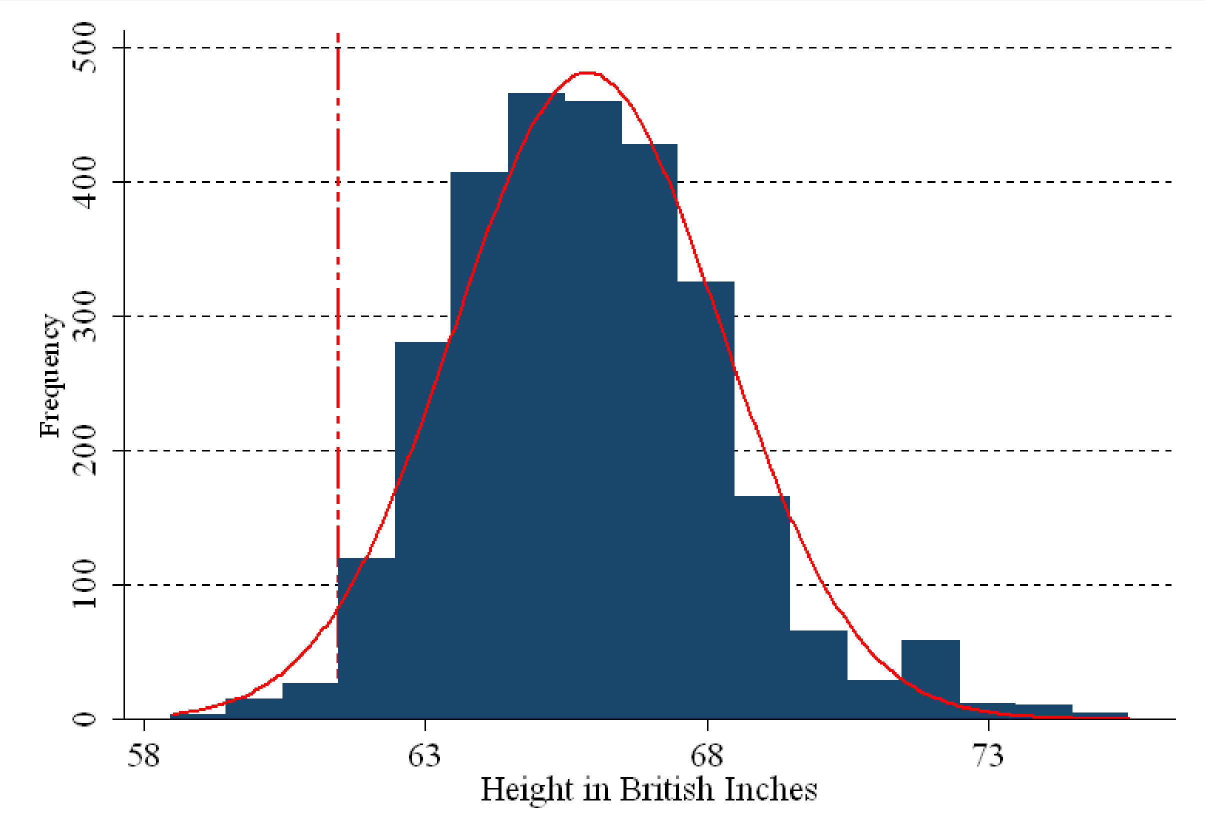
[35] It is noteworthy that the same (formal and effective) truncation point existed for the British German Legion (Coppola 2006).

Figure 2.7: Histogram of the Height Distribution



Source: Public Record Office, Holding WO15

A computational method for determining the effective truncation point has been suggested by Heintel (1996). A respective analysis confirms the truncation point obtained from visual inspection. The details are shown in appendix 1. Truncated data sets require special methods of analysis (Watcher and Trussell 1982, Komlos and Kim 1990, Komlos 2004) in order to avoid biased results. While several methods have been proposed, Truncated Maximum Likelihood Estimation leads to the best results.[36] This requires discarding all data below the truncation point, so our sample size is reduced to those taller than 61.5 inches.

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36 Restricting the standard deviation to a certain value (for instance, the known value of current population) has been suggested, but must be treated with care, as the proper value of the standard deviation is crucial for the results, but hard to properly estimate (Jacobs et al. 2004). Especially in cases where the population mean is not too close to the truncation point – as it is the case in this dataset – unrestricted likelihood estimation leads to satisfactory results (A'Hearn 2004).

Description of Origins

Some lack of accuracy in the data is introduced by regional circumstances: First of all, most Swiss cantons have the same name as their capital. This makes it impossible to distinguish between observations of urban and rural origin. In addition, several towns in the region have the same names: There was a Kingdom of Baden (with a city called Baden) in the German South bordering Switzerland while there is also a city Baden in the Canton Aargau; there is a city Freiburg just north of Basle in Germany as well as a canton Freiburg in Switzerland. Given the relative sizes (Baden, Aargau, had a population of 2,745 in 1850), observations indicating Baden as place of origin were considered to be German, while those indicating Freiburg were taken as residents of the respective canton.

Descriptive Statistics

Descriptive statistics of the sample are shown in Table 2.1. For the further analysis, we disregard those of non-Swiss origin (Table 1).[37] Hence, the dataset is reduced to 2,183 observations (prior discarding those below the MHR).[38] The dataset resembles to a reasonable extent the composition of the Swiss population on a cantonal level (Figure 2.8). The most notable difference is that the small cantons are significantly underrepresented, and that the two semi-cantons of Basle are strongly overrepresented in the data sample.[39]

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[37] About 80% (550 subjects) of the non-Swiss soldiers were of German origin, another 11% (75 subjects) were Italian. The remainder originated from nine other countries.

[38] Four additional observations were disregarded for obvious inaccurate records.

[39] This might indicate that the share of those with unspecified origin in the dataset were born in such small and remote villages that they favored to state “Switzerland” as their origin, or the answer was just omitted. On the other hand, it also indicates that the recruiters, who made the first contact with potential soldiers and then

Table 2.1: Composition of the Sample by Region and Age[40]

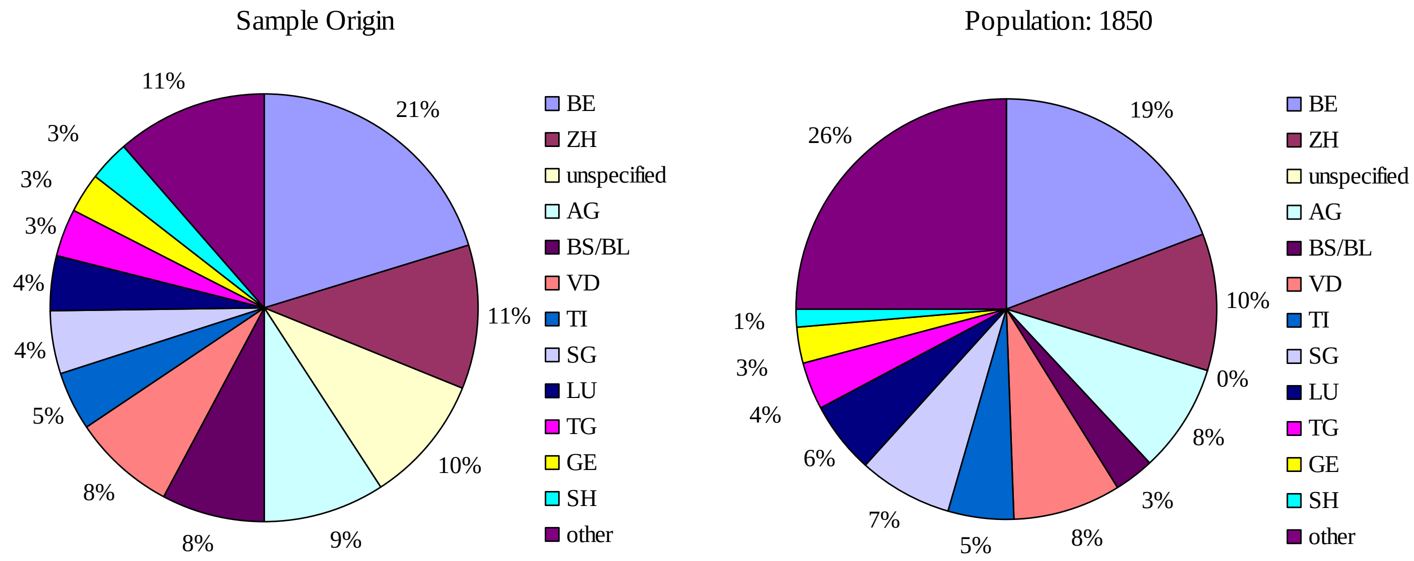
Canton	Abbr.	Birth Cohort 1816-1820	1821-1825	1826-1830	1831-1835	1836-1839	Total
Aargau	AG	2	33	58	77	30	200
Appenzell	AI/AR	1	3	1	5	2	12
Berne	BE	19	64	125	162	71	441
Basle	BS/BL	1	32	50	56	30	169
Fribourg	FR		7	8	23	7	45
Geneva	GE		8	23	24	13	68
Glarus	GL			1	2	1	4
Grisons	GR		3	6	13	2	24
Lucerne	LU	2	24	28	29	12	95
Neuchâtel	NE	2	11	14	13	5	45
Nidwald/Obwald	NW/OW	1	2	1	3		7
St. Gall	SG	1	27	27	27	16	98
Schaffhausen	SH	1	12	21	21	13	68
Solothurn	SO		13	20	22	8	63
Schwyz	SZ		0	4	3	1	8
Thurgovia	TG		9	23	32	10	74
Ticino	TI		13	28	47	13	101
Uri	UR			2	2	3	7
Vaud	VD		36	44	58	29	167
Valais	VS		5	6	6	1	18
Zug	ZG	1		2	9	4	16
Zurich	ZH	5	36	59	95	42	237
unspecified		2	6	22	29	4	63
not stated/ blanks		13	23	34	36	20	126
unknown			5	7	10	5	27
Total Swiss		**51**	**372**	**614**	**804**	**342**	**2183**
Non-Swiss		8	124	212	231	106	681
Total Sample		**59**	**496**	**826**	**1035**	**448**	**2864**

Source: Public Record Office, Holding WO15

sent them of the recruiting depots, most likely focused on cantons with larger number of inhabitants and higher population density instead of traveling to remote locations.

40 "Unspecified" refers to list entries that stated "Switzerland" as origin; "not stated" refers to blanks and "unknown" indicates list entries where the origin could not be identified.

Figure 2.8: Regional Composition of the Sample and the Swiss Population, c. 1850



Source: Public Record Office, Holding WO15, Hardegger et al. 1986
Note For abbreviations of Canton names, see Table 2.1.

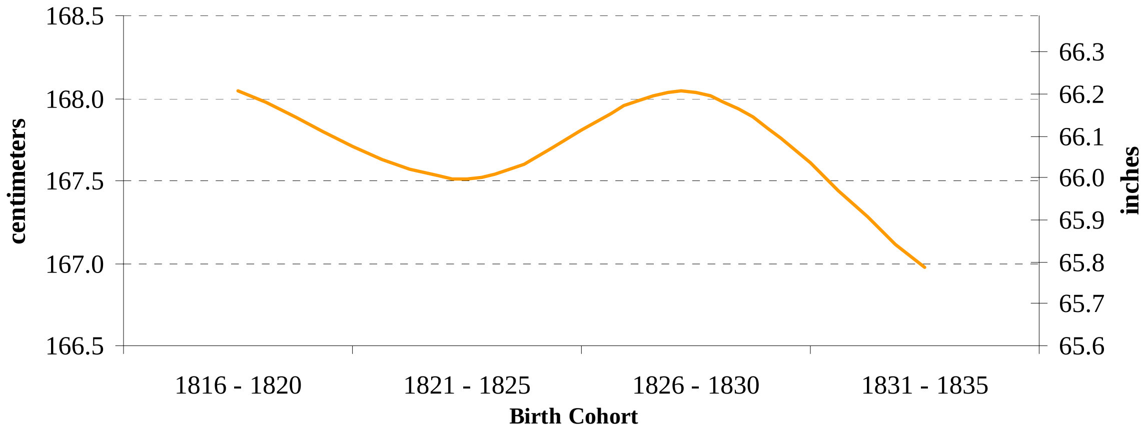
The latter may be related to the relative proximity of the main recruiting depot in Schlettstadt to Basle, but could also be due to the relatively high level of urbanization in the Basle region (Basle was Switzerland's second largest city at the time).

Findings

Time Trends of the Raw Data

The time trend in height is analyzed by birth cohorts including only those that can be assumed to have completed the growth process (i.e. those born before 1836 and hence aged 22 or older). Figure 2.9 shows the trend obtained by the raw data after those below the truncation point have been eliminated, as they might distort the trend. A trend analysis of the results predicted by regression analysis is shown later on. Over a period of 15 years from c. 1820 to c. 1835 average height declined by about 1.5 cm (0.6 inches), but these changes could be biased as they are not based on truncated regression. The quinquennial fluctuations, with about 1.1 to 1.3 cm (0.4 to 0.5 inches) do not appear unreasonable for five-year periods. Given the moderate sample size, particularly in the first period, a clear decline in nutritional status in Switzerland cannot be established by the data at hand.

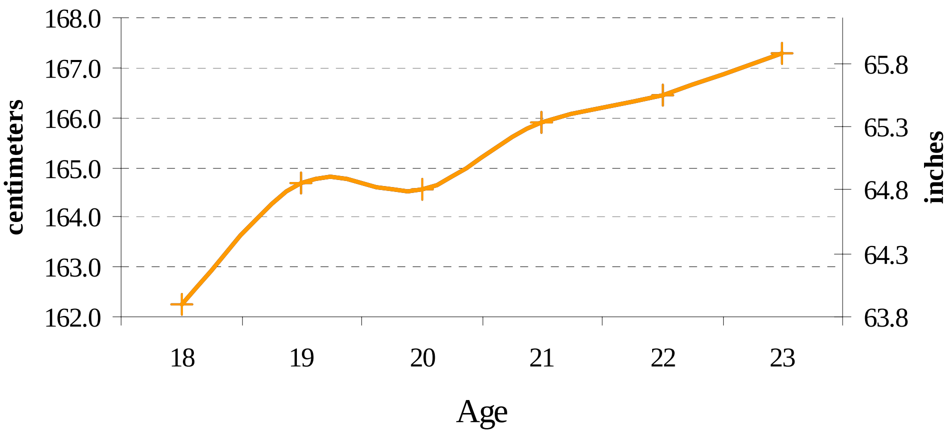
Figure 2.9: Time Trend in Height, Raw Data



Source: Public Record Office, Holding WO15

The data also contain records that pertain to subjects born in the years 1836 – 1840. At the time of measurement, these subjects had not yet finished their growth process. Thus, they are not included in Figure 2.9. In order to get a better understanding of how much those still in the growth process were shorter than the fully grown adults, Figure 2.10 shows the height by age profile of youth.

Figure 2.10: Growth Profile of Swiss Youths, 1856



Source: Public Record Office, Holding WO15

Regression Analysis of the Time Trend [41]

In order to estimate a time trend in the variations of height, we propose two basic specifications. The base model (Model 1) includes only those subjects that are old enough to have reached their final height. This is done in order to avoid any confusion between secular trends in stature and results that are outcomes of the growth process. In a second specification (Model 2), we include all observations and add control variables for the specific ages of those that did not attain final height yet. As all of those are part of the birth cohort 1835 – 1838, we cannot include a dummy variable for this birth cohort as this would introduce multicollinearity into the regression (Table 2.2).

Since we are dealing with a truncated dataset, we exploit the fact that the standard deviation of height distributions remains mostly unchanged between populations and is known to be about 6.86 cm or 2.7 inches (A'Hearn 2004). We restrict the truncated maximum likelihood estimation by fixing the standard deviation to this value, and rerun the specifications of the models 1 and 2 (labeled model 3 and model 4). The results obtained by the restricted specifications can be more reliable, especially if the truncation point is close to the mode of the sample. But even if there is a sufficient amount of observations between the truncation point and the mean, a comparison of the unrestricted regression results to the restricted ones helps to reassure that the results obtained are plausible.

[41] All estimations were done using the statistical software STATA 9.1

Table 2.2: Regression Results

Dependent variable: Height Variable	Model 1 adults only	Model 2	Model 3 adults only	Model 4
Birth Cohort				
1815 - 1819	0.008	0.008	0.009	0.009
	(1.331)	(1.350)	(1.418)	(1.418)
1820 - 1824	-0.629	-0.639	-0.672	-0.672
	(0.486)	(0.494)	(0.522)	(0.522)
1825 - 1829	Reference group	Reference group	Reference group	Reference group
1830 - 1834	-1.278**	-1.298**	-1.368**	-1.368**
	(0.379)	(0.385)	(0.404)	(0.404)
Age				
21 years (born 1835)		-0.733		-0.772
		(0.631)		(0.667)
20 years (born 1836)		-2.812**		-2.976**
		(0.540)		(0.572)
19 years (born 1837)		-3.305*		-3.504*
		(1.389)		(1.483)
18 years (born 1838)		-6.139**		-6.558**
		(1.663)		(1.794)
Intercept	167.563**	167.495**	167.246**	167.246**
	(0.283)	(0.290)	(0.298)	(0.298)
Standard deviation	6.194**	6.353**	6.860	6.860
	(0.177)	(0.172)	(restricted)	(restricted)
Number of obs.	1622	2143	1622	2143

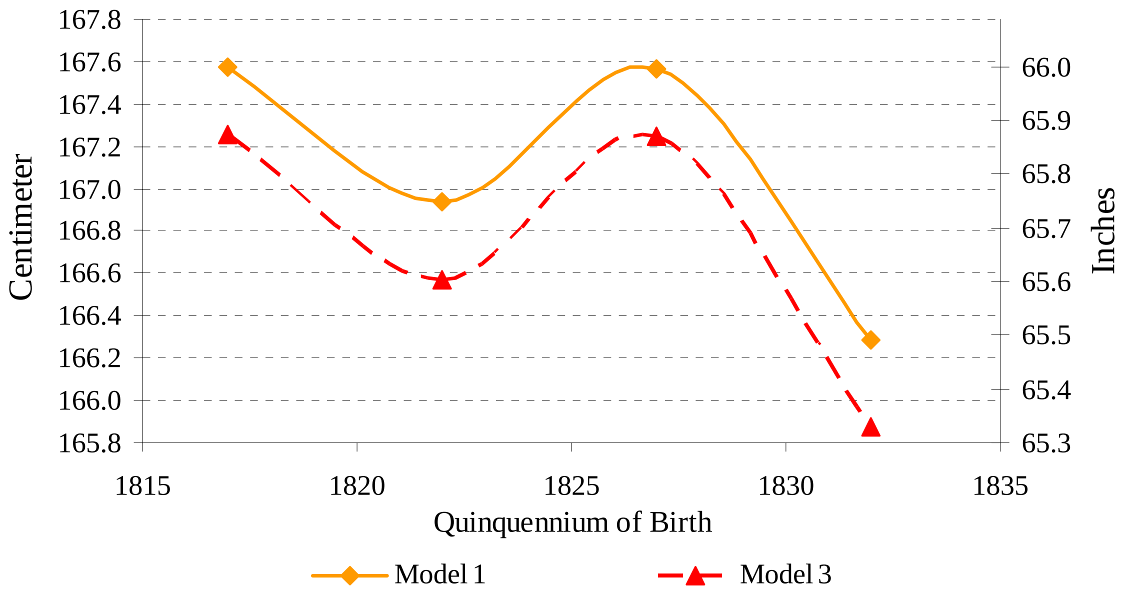
Notes: Results are presented in centimeters. 2.54 cm = 1 British inch.
Truncation point set at 156.21 cm (61.5 British inches)
Robust standard errors in parentheses
* significant at 5% level; ** significant at 1% level

Source: Public Record Office, Holding WO15

The fluctuations of up to 1.3 – 1.4 cm on a quinquennial basis are within a plausible range. In line with the analysis of the time trend in the raw data above, we note that across all models, those born in the first half of the 1830s are significantly shorter than those born five years before. Recalling Figure 2.6, the shorter stature of those born between 1831 and 1835 may be related to a nutritional shortage during the early years of life. Even though the disadvantageous development of the grain price/ income relationship in the early 1830s was not as severe as the one subsequent to the Napoleonic Wars, it still could have affected the final stature of this birth cohort, as it coincides with their most important period of growth. However, the small extent of the increase in grain prices and the even smaller increase in potato prices, which constituted the main portion of the diet of middle and lower classes in Switzerland, may raise doubt whether it is appropriate to speak of a nutritional crisis for that period. It may well be that the considerably larger nutritional crisis from 1847 to 1855 and the respective scarcity of food supply during the adolescence of those born between 1831 and 1835 has led to shorter final height. Current research by Straub and Pfister (2006) on Swiss heights during the 19th century based on the correlation of climatic indicators and final height suggests that especially the age bracket between 16 and 19 was sensitive to any disadvantageous nutritional environment.

Using the results obtained in the regression shown above, we calculate the time trends as they are estimated by the regression model. The results of model 1 and model 3 provide an upper and lower bound estimates of the Swiss male population (Figure 2.11) (we do not plot graphs

Figure 2.11: Time Trend in Height



Source: Table 2.2

for model 2 and 4, as the results are very similar to model 1 and 3, respectively). The graph exhibits considerable fluctuations in the stature of the sample population. Both models show an overall decrease from the late 1810s to the early 1830s. Heights declined by between 1.3 cm and 1.4 cm. But given the pattern at hand, it is more appropriate to speak of fluctuations in stature than of a downward trend.

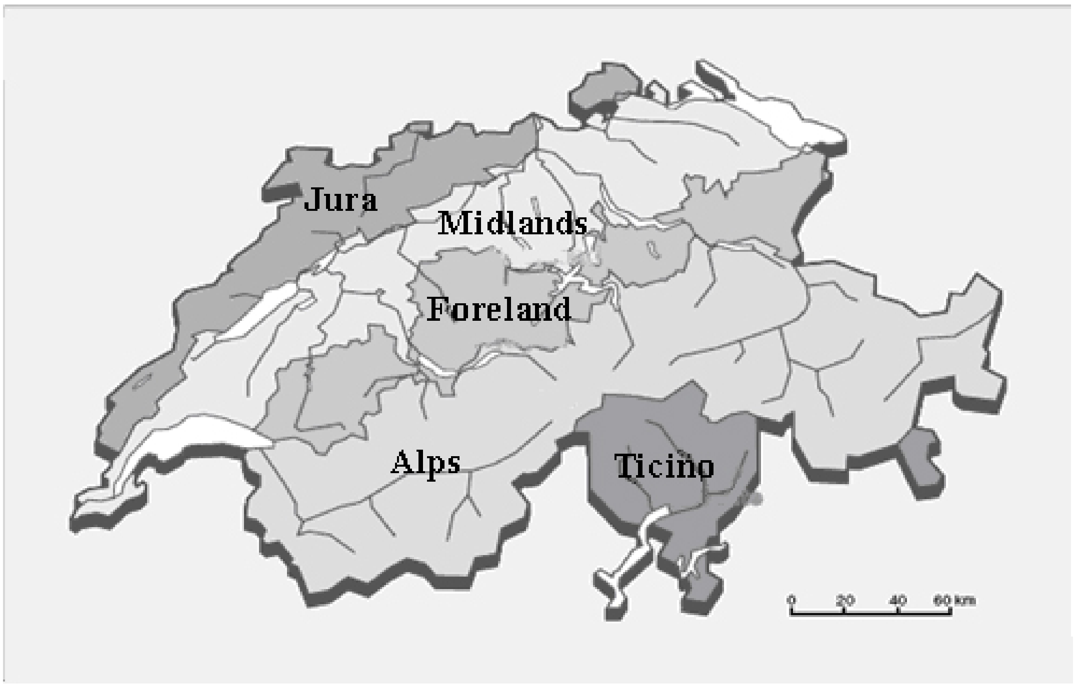
Spatial Effects

We also perform regression analysis in order to explore any spatial effects. All results should be interpreted with care: as the data collected by the British War Office allows only for identification of the canton of origin, any statements about the ecological condition may be flawed because they may not refer to canton of birth. Moreover, some of the cantons are quite heterogeneous: Berne for example, stretches from the lower regions with extensive grain agriculture into the uninhabitable mountain regions. Hence, the results should be taken as indicative and preliminary only.

Several ways of sorting the cantons into meaningful groups were employed. This includes grouping the cantons by population density, population growth, regional divisions and ecological groups. While sorting the cantons by population density and population growth is rather straight-forward and readily interpretable, other regional divisions may not provide an intuitive economic explanation.

Switzerland is traditionally divided into seven geographical regions: The western, French dominated part around Lake Geneva, the Espace Mittelland, covering the large area between the Jurassic Mountains and the Alps in the West, the region of Zurich, North-western Switzerland in the area between Zurich and Basle, central Switzerland in the middle of the country, representing the traditional origin of the Swiss confederation, the canton Ticino as the only region south of the Alps and eastern Switzerland from Lake Constance along the eastern border of Switzerland into the Alps. In order to group the cantons of origin into ecologically meaningful regions, the cantons were grouped by the forestry zones of modern day Switzerland (see Figure 2.12).

Figure 2.12 Forestry Zones in Switzerland



Source: Federal Office of Statistics

Since the forestry zones generally do not follow cantonal borders, each canton was grouped into the region most typical for it, depending on where the majority of its population lived (Table 2.3).

Table 2.3: Classification of Cantons by Forestry Zones

Region	Cantons
Jura region	Basle, Neuchâtel, Schaffhausen, Solothurn
Midlands	Aargau, Berne, Geneva, Thurgovia, Vaud, Zug, Zurich
Foreland of the Alps	Appenzell, Fribourg, Lucerne, Nidwald/ Obwald, Schwyz, St. Gallen
Alpine region	Glarus, Grisons, Uri, Valais
Ticino region	Ticino

Source: Based upon Figure 2.12

Neither of the different grouping methods led to any meaningful significant results when added as control variables (results are not reported here).[42]

[42] Subjects of unknown or unspecified origin show up as taller in all specifications; but any inference based on this result would require speculative assumptions about those who could not be assigned to a specific origin.

Moreover, the coefficients of the time trend did not change meaningfully after the spatial controls were included in the regressions. Some of the results – even though they are not significant – still should be mentioned: People from areas with low population density appear slightly shorter than those from regions with higher density. This result is somewhat puzzling, as previous research has shown that low population density has a favorable impact on heights (Komlos and Lauderdale 2007). In the special case of Switzerland, a low population density can be the result of large parts of uninhabitable mountainous terrain, which would imply a less propitious environment. This notion is also supported by the specification that uses the ecological zone proxies, as the alpine subjects turn out to be the shortest. This seems intuitive, given that nutrients are scarcer in regions lacking fertile soil.

It is also interesting to note that people from the "ecological midlands" of Switzerland were shorter than their counterparts from the Alpine Foreland. This seems to indicate a greater abundance of nutrients in the less-integrated region of the lower Alps. Considering the more hilly geology in the Foreland of the Alps, dairy agriculture is likely to have been more common in these regions. This implies better access to milk, one of the most important sources of protein (similar effects of the proximity to sources of milk have been found by Baten (1997) for the case of Bavaria) that was important for the growth process.[43] The remoteness of these regions also might have served as insulation from integration into the European grain market.

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[43] Baten made this argument to support the data of Munich citizens being taller than average; in our data, however, inhabitants of Zurich were actually shorter than the Swiss average.

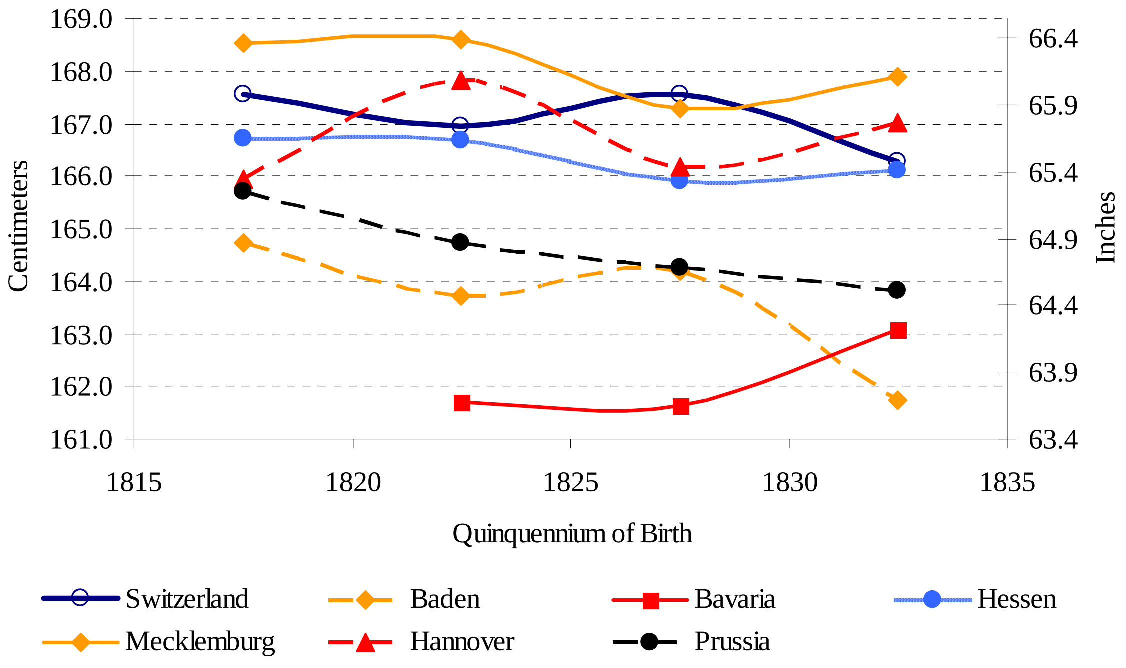
International Comparison

Comparisons of height datasets require special care: Different measurement methods, different samples with respect to age, origin and ethnic background, among others, can easily affect the results and obstruct meaningful comparison. As stated above, the sample at hand is most likely not representative of the Swiss population, but stems from the lower segments of the society. However, for the case of the dataset at hand, a comparison between the results presented here and those obtained with respect to the British German legion by Coppola (2006) seems most appropriate. For a more international view, we also add estimates of the trend in stature among soldiers during the first half of the 19th century in several other European countries.

British German Legion

The analysis of data pertaining to soldiers from the British German legion recruited by the Government for the Crimean War provides estimates of the trend in physical stature of Germans that are likely to stem from a similar socio-economic class as the Swiss subjects. Coppola (2006) provides estimates for different regions within Germany (Figure 2.13). The Swiss heights seem to be around the level of the population from Hannover, which in turn is above the average of the German States. The soldiers from the northern states were slightly taller, while those from Bavaria and Baden were shorter. This regional pattern is interesting, since this implies that the Swiss soldiers exceeded their immediate northern neighbors (Baden and – in parts – Bavaria) in stature. But the spatial differences may also be influenced by the recruiting practice employed during the recruitment of the German legion.

Figure 2.13: Height of British Mercenaries During the Crimean War (by Region)



Sources: Germany States: Coppola (2006), Switzerland: Table 2.2

The gathering point of the British German Legion was located on Heligoland, an archipelago in the North Sea, and no financial aid was given to men intending to join the German legion (Bayley 1977).[44] Thus, it is likely that especially unskilled and poor subjects are included in the estimates for the southern German states.

Comparison with Other Data

An international view confirms an above average Biological Standard of Living in Switzerland during the first half of the 19th century. The fluctuating trend in height over the time from 1815 to 1830 fits well into the experience of other continental European armies such as the Bavarian, French and Hungarian soldiers (Figure 2.14). The onset of a decline, as it is apparent in the last birth cohort under consideration, matches the remainder of armies

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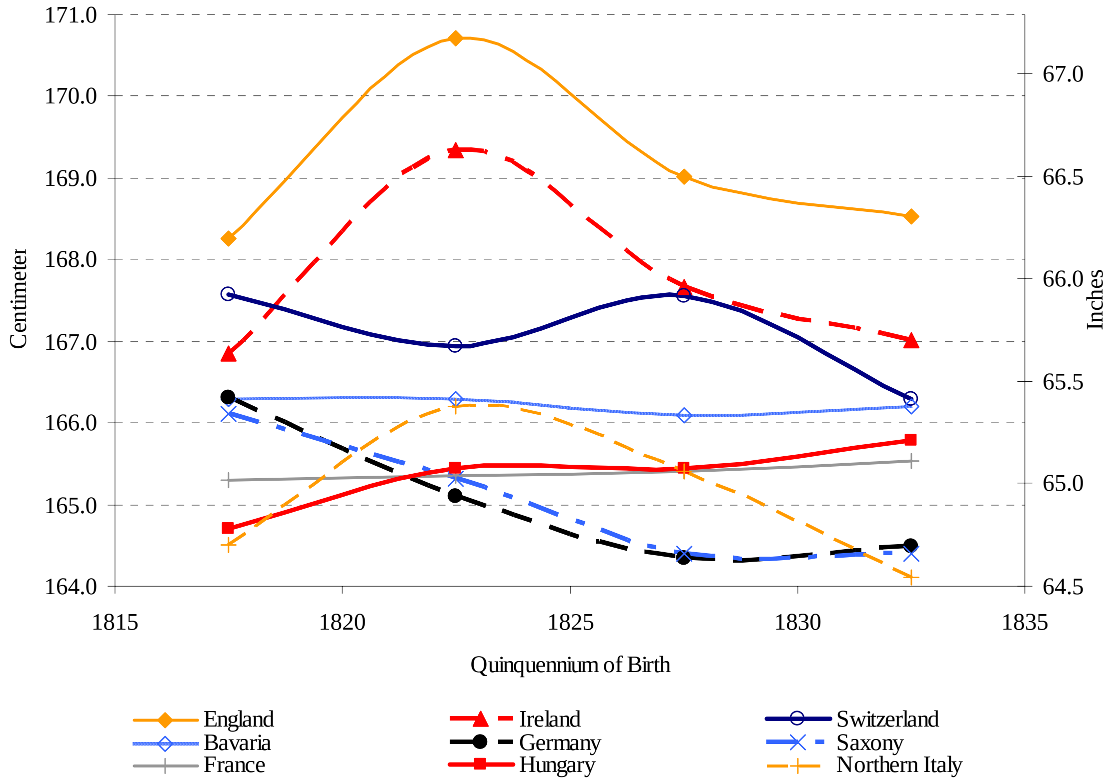
44 For further details about the recruitment practice of the German legion and the potential impact on the socio-economic and spatial composition of it, see Coppola (2006).

shown in Figure 2.14, with a lag of 5 to 10 years. While British and Italian heights recouped after the end of the Napoleonic Wars to reach a temporary peak in the 1820s, German heights began to decline about 10 years before. Potentially, the unique development of the industrial

Figure 2.14 Height of European Soldiers, Born 1815-1835



Sources: England and Ireland: Cinnirella (2007, preliminary estimates), Bavaria: Baten (2000), Germany: Coppola (2006), Saxony: Cinnirella (2006, preliminary estimates), France: Weir (1997), Hungary: A'Hearn (2003) based on Komlos (1989), Northern Italy: A'Hearn (2003), Switzerland: Table 2.2

revolution in Switzerland, with a lower degree of urbanization and hence less of urban industrial proletariat, might have delayed the general downturn in the Biological Standard of Living as it has been witnessed in the development of physical stature of other European and North American heights. This phenomenon, referred to as early-industrial growth puzzle (Komlos 1998, Haines 1998, Sunder 2004)[45] was apparently less pronounced (or occurred at a later point in time) in Switzerland than in other countries. This notion is further supported by

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45 In the North American context this pattern of declining heights in the 1830s is often referred to as the "Antebellum puzzle" (Komlos 1998).

absolute advantage in stature that Swiss soldiers enjoyed over their immediate neighbors in Germany, Northern Italy and France.

Conclusion

Using data on the height of Swiss soldiers in British service, we are able to shed some light on the biological standard of living in Switzerland in the first half of the 19th century. Given the shortage of other (reliable) measures of well-being for that time period, anthropometric data enable us to document a decline in the average biological standard of living among the Swiss population among those born in the 1830s. Despite the severe limitations of the dataset described above and the subsequent provisional character of the results, there are solid indications of fluctuations in nutritional status. In spite of the fact that mortality rates declined and real wages increased, the (at least temporary) decline in height in Switzerland is indicative of the probable decline in food intake, brought about by an increase in food prices. The Swiss downturn in height corresponds with those that occurred in several other countries (Cinnirella 2007 and 2006, Coppola 2006, Sunder 2004, A'Hearn 2003, Komlos 1998, Haines 1998), but began at a later point time and was less pronounced. As the time period covered is limited, an extension of the research into the development of the biological standard of living during the middle of the 19th century in Switzerland is needed to confirm that the downturn observed was part of a longer decline. Furthermore, more detailed information on spatial differences, especially in the urban/rural dichotomy, is required in order to assess the impact of the industrial revolution on the well-being in Switzerland.

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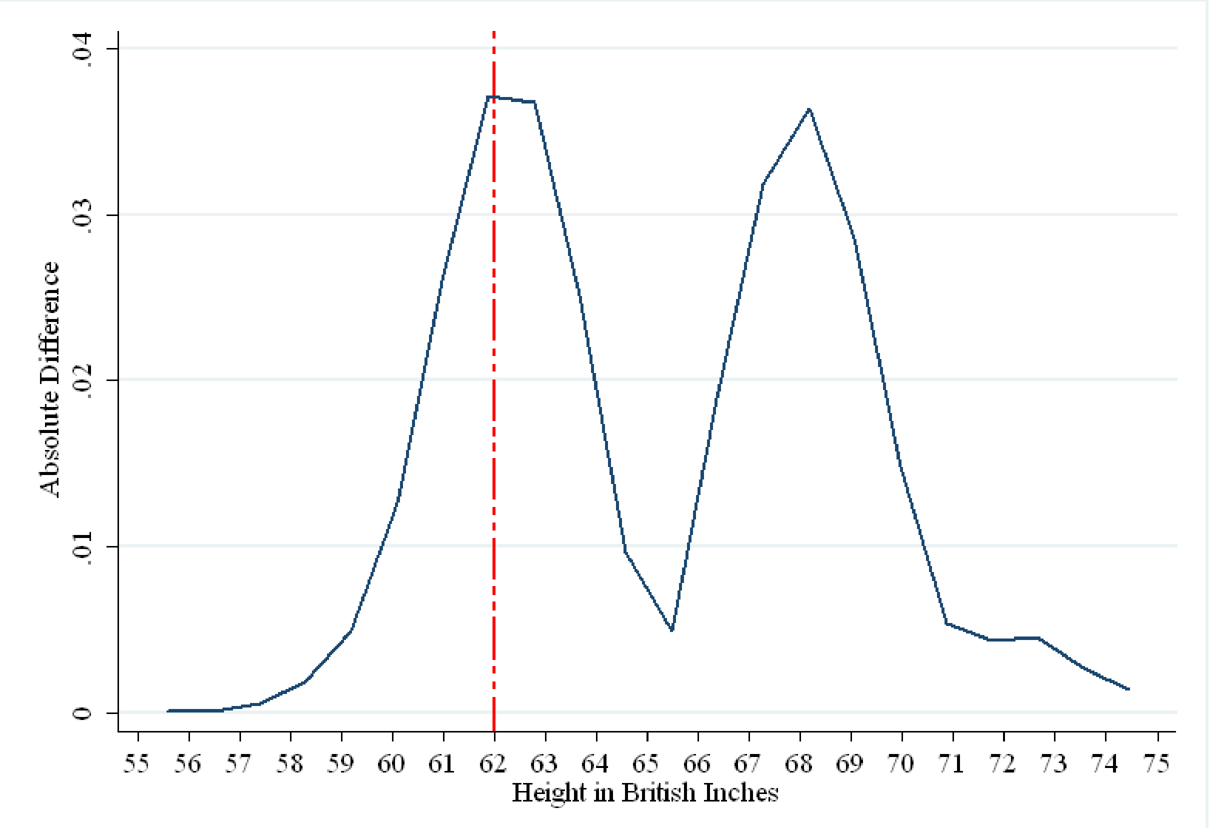
Appendix I

The estimation method for a truncation point suggested by Heintel (1996) is based on the absolute first differences of the height distribution. Since the density of the distribution becomes low beneath the truncation point, and remains high above the truncation point (in the case of a minimum height requirement), the absolute difference will be greatest at the truncation point. Figure 2.15 shows the plot of the absolute first differences in the height distribution.

Figure 2.15: Absolute First Difference in the Height Distribution



Source: Public Record Office, Holding WO 15

The vertical dashed line indicates the position of the truncation point (62.0 British inches) as determined by the visual inspection of the histogram. The computational approach of using the absolute first differences confirms this result, as the absolute difference is greatest at this point.

PART III: The Physical Stature and BMI Values of U.S. Army Personnel in 1988

Abstract

The U.S. Army's 1988 Anthropometric Survey (ANSUR) data is analyzed in order to estimate the secular trend physical stature and body mass index while controlling for ethnic composition as well as place of birth. Separate analysis for blacks and whites stratified by gender is presented. The stature of the U.S. Army personnel remained constant for those born between 1950 and 1970, and no substantial ethnic or spatial effects were found. These results add further support to results based on the National Health and Nutrition Examination Survey data as well as on a smaller sample of military personnel.

Introduction

The mean physical stature attained by a population is a function of the cumulative (net) nutritional experience during infancy, childhood and adolescence in that population. The improvements in general living standards over the last one and a half century have led to a secular increase in the stature of most populations. However, the American experience in this regard during the course of the 20th century is puzzling: After being the tallest in the world for two centuries (Komlos 2001, Komlos and Baur 2004) the U.S. population appears to have stopped growing during the middle of the 20th century. Because most Western- and Northern-European populations continued to grow, the height of the U.S. population declined relative to many industrial populations. Most European population grew by about 1 cm per decade in the last one and a half centuries. In contrast, American men were already 173 cm tall in the middle of the 18th century and increased by merely 3-4 cm in the course of 250 years (A’Hearn 1998, Cole 2003, Komlos and Baur 2004). As consequence of the differences in the secular trend, Dutch males born between 1930 and 1940 have overtaken their U.S. counterparts in height, while Germans, Danish, Norwegians and others followed in the 1950s and 1960s. Today, Swedes, Czechs, Finns, Belgians and Canadians also enjoy advantages in stature over the U.S. population (Komlos and Lauderdale 2007a, Sunder 2003, Komlos and Kriwy 2002).

Since adult height is an indicator of living conditions (mostly dietary and disease) during childhood and adolescence (Steckel 1995), a stagnation of stature in times of growth in real per capita income is puzzling. Most of the studies analyzing the secular trend in the U.S. population (Ogden 2004, Komlos and Baur 2004, Komlos and Lauderdale 2007a, b) are relying on surveys that includes only broad information on the race of subjects. Considering the knowledge about differences in heights of the European population (Cavelaars et al. 2000), the question of the impact of ethnicity on the heights observed in the United States deserves further investigation. Underlying changes in the ethnical composition of the white and black population that could not be identified by previous studies might afflict the trend prevailing in the U.S. population. This paper aims to investigate the impact of ethnicity by analyzing data pertaining to soldiers serving in the U.S. Army in 1988, collected in the United States Army 1988 Anthropometric Survey (the ANSUR database). Even though army personnel is not representative of the U.S. population but rather are drawn from mostly lower segments thereof, the impact of ethnicity is not likely to differ between socio-economic segments. Because of the scarcity of data sets including detailed ethnic information it is worthwhile to explore the effect of more detailed ethnic characteristics on the height of the U.S. military personnel and to consider the impact of transferring the findings to the U.S. population.

Previous Research on the Secular Trend in U.S. Mean Stature

Investigating the phenomenon of stagnating heights in the U.S., Komlos and Baur (2004) analyze NHANES III survey data, which was conducted between 1988 and 1994. They show that the height of U.S. born men and women stagnated among the cohorts born in the 1950s;

females born in that period even experienced a slight decline compared to those born in the preceding cohorts.

Komlos and Lauderdale (2007a) used a combined sample of the NHANES I – IV to pinpoint the end of the secular increase in U.S. heights. They find that both male and female heights remained unchanged between those born c. 1955 and 1975. Black female height has remained unchanged since the 1925 birth cohorts. Results indicating a more recent increase in height among the male subsample are based on small numbers of observations and therefore need to be considered as preliminary. This result has been further corroborated, in the main, by Komlos and Lauderdale (2007b) using data of a commercial survey.

While the studies mentioned above limit the analysis to U.S. born subjects, stratify by race and gender and also control for educational levels and household income, the subject's ethnicity and its parent's ethnicity are not available in the above surveys.

Providing preliminary estimates the effects of ethnicity and spatial effects, Komlos (2006) has analyzed a subset of the ANSUR database which was created to be representative of U.S. Army personnel. Even though the U.S. Army is not representative of the general U.S. population, the findings confirm the results obtained by the NHANES data: the increase in height came to an end by the late 1950s, with the exception of white females who did stop growing five years later than the remainder of the sample. Komlos also investigates the influence of the ethnicity and is not able to detect a consistent pattern of influence on height. Furthermore, no spatial effects become apparent in his analysis. This paper expands the analysis of Komlos by using a larger portion of the measured sample in the ANSUR database: in the data collection process, subgroups of the U.S. Army were intentionally over-sampled in order to be able to adjust the representative subset to changes in the composition of the U.S. Army (Gordon et al. 1989). As the main intention of this paper is not to report representative results for the U.S. Army, but to investigate the impact of subject's and parental ethnicity on mean stature, the maximum of available data should be utilized in the analysis. The dataset being analyzed is about twice as large as the one analyzed by Komlos (2006).

Data and Methods

The data collected intentionally over-sampled several age and race categories in order to allow for adaptation to future changes in the composition of the military (Gordon et al. 1989). Hence, the data being analyzed is neither representative of the U.S. population nor of the U.S. military forces. The full dataset contains information on the stature, weight and sex of the subject as well as birthplace, racial and ethnic background of the subject and its parents.[46] The dataset contains 8,537 observations, pertaining to subjects born between 1940 and 1970. Of these subjects, 1,369 are non-U.S. born immigrants that are excluded from the analysis. Further limitation is required as in a cross-sectional dataset such as the ANSUR database it is not possible to distinguish between variations in stature as a result of a secular trend and changes inferred by age. In modern populations, maximum height is reached – on average – at the age of 18-19 for boys and two years earlier for girls (Kuczmarski 2000, Bogin 1999, Marshall 1979, van Wieringen 1979,[47] Hamill et al. 1977, Tanner and Whitehouse 1976). The exact timing at what age heights begin to decline is still subject to debate, as it is difficult to disentangle the secular increase in stature from the onset of the decline induced by age. Studies of the Caucasian U.S. American population – for which the secular increase came to a

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[46] The full ANSUR database includes measurement of 132 anthropometric dimensions (Gordon et al. 1989, Clauser et al. 1988); in the extract available for this study, only mean stature and weight are included.

[47] van Wieringen also presents a discussion of secular changes in the growth pattern and the acceleration in stature growth. While 19th century populations continued to grow past 20 years, the growth pattern (and the time of peak velocity during the adolescent growth spurt) has shifted towards younger ages, leading to an earlier attainment of final stature.

halt in the 20th century – suggest that the age-related decrease begins at the age of about 30 to 35, but remains minimal up to the age of about 40 to 44 and becomes more notable past the age of 50 years (Friedlaender et al. 1977, Cline et al. 1989, Galloway et al. 1990). To be on the safe side, only adults in the age from 20 to 43 are included in the analysis. This limitation reduces the dataset by another 935 observations, so the analysis is based on the 6,233 U.S-born members of U.S. Army personnel (Table 3.1).

Table 3.1: Composition of the Sample

	Females	Males	Total
Whites	1,148	1,338	2,486
Blacks	1,141	1,235	2,376
Hispanics	176	520	696
Asian	30	81	111
other	190	374	564
Total	2,685	3,548	6,233

Source: ANSUR database

The analysis focuses on Whites and Blacks,[48] because the small number of observations in the other ethnic groups prohibits meaningful analysis. Time trends in height and body mass index (BMI) are estimated using OLS regression analysis with and without controlling for ethnic and socioeconomic background by race and sex. An important advantage of the ANSUR dataset is that it provides self-identified information[49] on the ethnicity (obtained in an interview, see Clauser et al. 1988) and place of birth of the both the subject and its parents

48 While the questionnaire given to the soldiers asked them to differentiate between White (not of Hispanic Origin), Black (not of Hispanic Origin) and Hispanic, a number of black soldiers reported to be of Latin-American ethnicity (Table 3.2).

49 Self-identified information induces potential biases into the reported data, as it is unclear how subjects whose ancestors were of different ethnicities stated their ethnicity. Considering the number of subjects that report themselves as of American ethnicity, it seems reasonable to assume that subjects who do not have an attachment to a specific ethnic group (as consequence of being a hybrid of different ethnicities) used this classification.

Table 3.2: Ethnical and Spatial Composition of the Sample

	White Females	White Males	Black Females	Black Males
	N	N	N	N
Birth Cohort				
1945-1949 (aged 39-43)	41	87	25	58
1950-1954 (aged 34-38)	144	164	118	133
1955-1959 (aged 29-33)	214	219	256	234
1960-1964 (aged 24-28)	354	361	364	329
1965-1968 (aged 20-23)	395	507	378	481
Subject's Military Rank				
Commissioned Officer	273	149	85	40
Warrent Officer/ Enlisted Man	875	1189	1056	1195
Subject's Ethnicity				
American	700	858	141	284
North European	360	421		
South European	37	22		
East European	38	26		
African			983	945
Latin American			11	2
Unknown	13	11	5	4
Subject's Mother's Ethnicity				
American	327	522	137	286
North European	661	675	2	1
South European	40	34		1
East European	67	55		
African			963	932
Latin American			25	5
Unknown	53	50	14	10
Subject's Father's Ethnicity				
American	315	496	126	273
North European	645	696	3	
South European	50	33		1
East European	71	45		
African			956	931
Latin American		1	23	9
Unknown	67	67	31	21
Subject's Birthplace				
Mid Atlantic	181	175	152	145
East North Central	269	296	159	169
East South Central	83	87	189	198
West North Central	133	137	38	34
West South Central	63	95	115	141
Mountain	52	55	10	5
New England	73	66	15	7
Pacific	128	178	20	41
South Atlantic	163	248	440	493
US - not stated	3	1		
Total	1148	1338	1138	1233

Source: ANSUR database

that is not available in the NHANES surveys. The ethnical information given by the subjects' examined is grouped into categories: Northern European, Southern European and Eastern European for Whites,[50] and African or Latin American for Blacks. For both races, a separate category of "American" ethnicity is included to capture those who identified themselves as being of American ethnicity. On the other hand, there is a downside to the ANSUR database as it does not include information on well-established correlates of physical stature such as level of education and the economic background of the subjects.[51] Information on the place of birth in the ANSUR database is aggregated to the state level; for the analysis, the states are grouped into divisions according to the practice of the U.S. Bureau of the Census (see appendix I for an overview map). Table 3.2 summarizes the information on the ethnical background of the subjects and the regional distributions of the birth place by race and sex.

A visual inspection of the distribution of the heights for normality is required prior to any regression analysis, as the U.S. military imposes certain height requirements (Figure 3.1).[52] The U.S. Army considers a height below 60 inches (152.4 cm) for men and 58 inches (147.32 cm) for women as well as a height above 80 inches (203.2 cm) for both genders as disqualifying for military service (Army Regulation 40-501 2006). However, the height requirements do not lead to an obvious deformation of the height distribution. Najjar and

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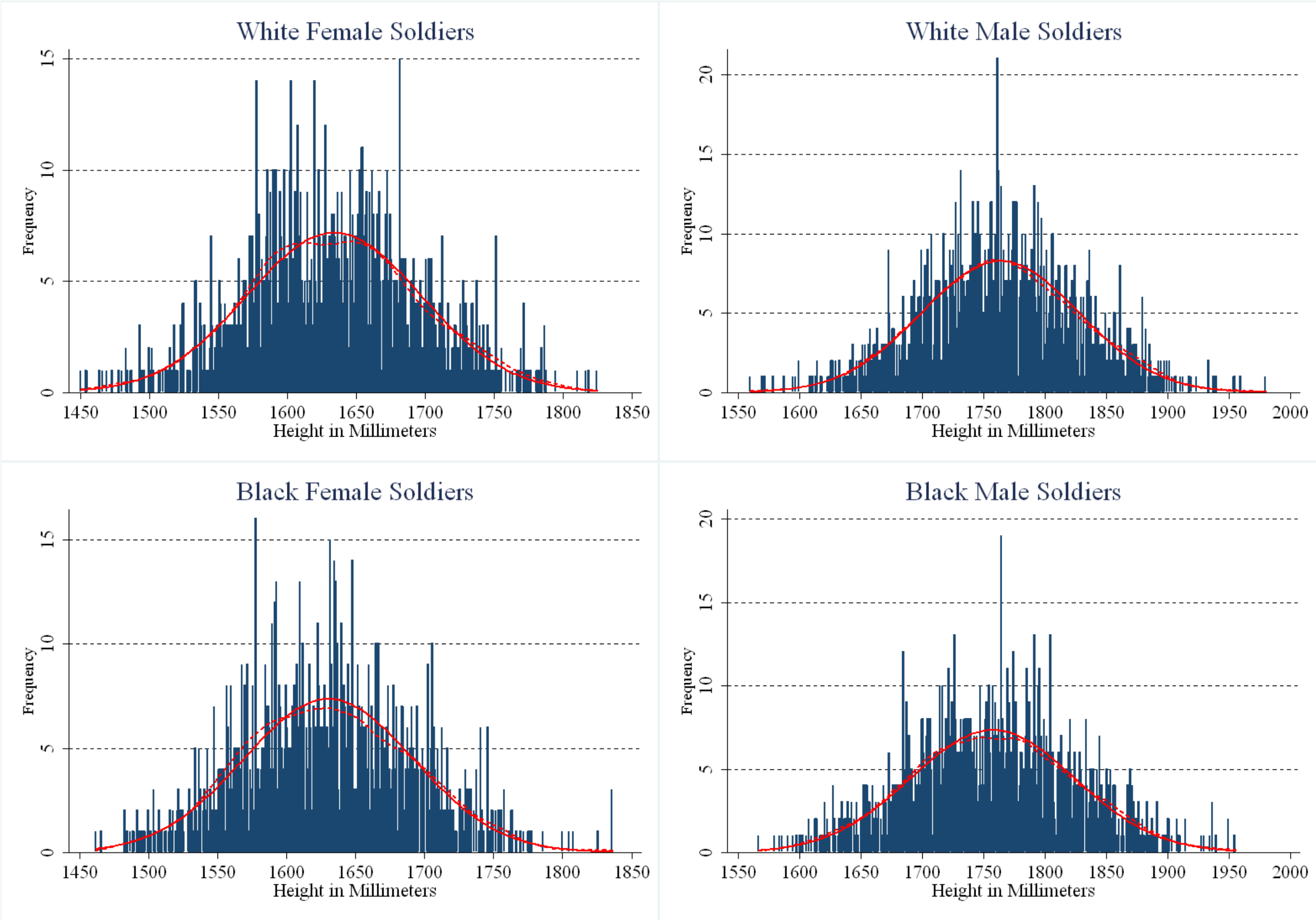
[50] "Northern European" constitutes, in the main, of subjects that identified themselves as of British, Irish, German, French and Scandinavian origin. "Southern European" includes mostly Italians and Greek (Portuguese and Spaniards were excluded as they were listed as Hispanics), while "Eastern European" captures Poles, Czechs, Hungarians other states further to the East.

[51] For a discussion of the impact of these factors, see Komlos (1994).

[52] An extensive discussion of the anthropometric requirements imposed by the different U.S. military services can be found in Gordon and Friedl (1994).

Rowland (1987) report the range from the 1st to the 99th percentile in the NHANES II sample, which is representative of the U.S. population as 62.6 to 75.6 inches (159.0 to 192.0 cm) for males and 57.6 to 69.7 (146.3 to 177.0 cm) inches for females, so the enlistment restrictions affect only a very slim part of the U.S. population. Thus, the data can be treated as normally distributed and therefore allows the application Ordinary Least Squares (OLS)[53] regression analysis to analyze the data (Komlos and Kim 1990).

Figure 3.1: Histograms of Stature of U.S. Army Personnel



Source: ANSUR database
Note: Solid line marks a normal density plot, while the dashed line marks the kernel density estimate.

53 Regression analysis was conducted using the software STATA 9.1.

Furthermore, there seems to be heaping on some numbers.[54] Yet, systematic rounding does not introduce a significant bias, since upward and downward rounding tends to cancel each other (Komlos 2004).

Since the dataset also includes information on the weight of the soldiers, we supplement the analysis of the physical stature by an analysis of the Body Mass Index (BMI).[55] BMI provides an indication of recent nutritional experience. The U.S. military also imposes requirements regarding weight at the time of enlistment. There are height and age-specific minimum and maximum weights stratified by gender. For instance, a male subject aged between 21 and 27 with a stature of 68 inches (172.72 cm) must have a weight between 115 and 181 pounds (52.27 to 82.27 kg) corresponding to a BMI range of 17.5-27.6 (Army Regulation 40-501 2006). If a recruit exceeds the maximum value, his body fat is measured, and if the age specific value of 26% body fat is exceeded, the individual is rejected for service.

The presumption of relative fitness in the military is supported by the data at hand (Figure 3.4). While Flegal et al. (2002) report a prevalence of obesity among the 20-39 years old of 14.9% for males and 20.6% for females based on the NHANES III data, in our sample (which includes also those up to the age of 48) only about 5.2% are considered obese. The military personnel weigh less than the American population at large due to weight requirements at the

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[54] For instance, there are 14 white females with a measured height of 162.0 cm, while only 3 (5) subjects with a height of 161.9 cm (162.1 cm) are reported. While this is a typical case of rounding towards nearby even figures, other cases seem to be random: There are 15 females with a height of 168.2 cm, while the neighboring values of 168.1 and 168.3 list only 4 and 6 observations, respectively.

[55] BMI is defined as weight (in kg) over stature (in m) to the power of two. This actually constitutes a measurement unit of pressure that is not considered to be very useful when discussing BMI. Therefore, the unit is frequently omitted.

Figure 3.2: Histograms of BMI of U.S. Army Personnel

Source: ANSUR database
Note: Solid line marks a normal density plot, while the dashed line marks the kernel density estimate.

time of entry, and more importantly, the nature of the daily work of soldiers. Hence, the analysis of a group so unique with respect to the physical requirements and fitness provides only limited insights on ethnic and spatial effects, so the results will be discussed in a brief manner only.

For the analysis of the physical stature, the sample is divided into four different subsets stratified by race and sex. The basic setup in Model 1 uses only dummy variables for the quinquennium of birth and a control variable whether the subject is a commissioned officer. Model 2 adds dummies for the subject's ethnicity. Next, the subject's mother's ethnicity is added (Model 3), while Model 4 includes the father's ethnicity instead. Model 5 is focused on the analysis of spatial effects by using uses the specification of Model 2 and adding variables for the place of birth of the subject. Finally, Model 6 uses the full set of controls by combining Model 5 with control dummies for the ethnicity of the subject and its parents. In the analysis of the BMI, the data is stratified in the same manner, but only Model 6 is employed in the regression analysis.

Results

Stature of U.S. Military Personnel

The results of the OLS regression results of determinates of mean stature are provided in Table 3.3 through Table 3.6. A plot sketching the secular trend in stature is shown in Figure 3.3.

In all four subsamples, mean heights (estimated by model 1) stagnated with slight fluctuations within the range of 1 cm for soldiers born 1950 to 1970. Since the composition of the U.S. Army changed subsequent to the transition to a volunteer army in 1973, the estimate for soldiers born 1945 and 1950 are likely to represent a different subset of the population. After c. 1950, the composition is more homogeneous. Both white and black female soldiers remained near the level of 163.0 cm; there are some slight differences in the timing of the fluctuations, but in the main there is no significant difference between white and black females soldiers. With respect to males, white soldiers (176.3 cm) enjoy a slight advantage of 0.6 cm in height over their black counterparts (175.7 cm). Again, there is some variation in the timing, but in a range of just 0.5 cm. For all four groups, heights in the late 1960s were essentially the same as they were 15 years before in the early 1950s. As expected, commissioned officers tended to be taller; the effect is significant for female soldiers (white and black) among whom the enlisted personnel are about 1.2 cm shorter than the officers.

Table 3.3: Height of U.S. Born White Female Soldiers, Aged Between 20 and 43

Dependent Variable: Stature Variable	Model 1	(Standard Error)	Model 2	(Standard Error)	Model 3	(Standard Error)	Model 4	(Standard Error)	Model 5	(Standard Error)	Model 6	(Standard Error)
Birth Cohort												
1945 - 1949	18.33*	(10.22)	17.76*	(10.40)	17.97*	(10.44)	18.77*	(10.49)	18.23*	(9.93)	19.02*	(10.22)
1950 - 1954	-1.69	(6.85)	-1.89	(6.88)	-2.22	(6.83)	-2.14	(6.85)	-1.37	(6.80)	-1.81	(6.77)
1955 - 1959	Reference		Reference		Reference		Reference		Reference		Reference	
1960 - 1964	7.47	(5.67)	7.74	(5.67)	7.78	(5.67)	7.70	(5.69)	7.62	(5.71)	8.16	(5.73)
1965 - 1969	2.30	(5.56)	2.49	(5.54)	2.41	(5.59)	2.49	(5.55)	2.42	(5.62)	2.72	(5.65)
Military Rank												
Commissioned Officer	12.70***	(4.51)	12.35***	(4.53)	12.18***	(4.54)	11.95***	(4.57)	11.86***	(4.56)	11.29**	(4.62)
Enlisted Personnel	Reference		Reference		Reference		Reference		Reference		Reference	
Subject's Ethnicity												
American			Reference		Reference		Reference				Reference	
North European			6.92*	(4.17)	5.09	(4.60)	6.03	(4.69)			4.42	(4.89)
South European			-5.38	(13.11)	1.91	(16.85)	-7.74	(15.56)			-0.44	(19.41)
East European			10.32	(10.00)	8.21	(11.95)	8.99	(12.75)			6.66	(13.93)
other			-12.76	(11.65)	-10.56	(13.09)	-1.91	(13.55)			-2.81	(14.41)
Subject's Mother's Ethnicity												
American					Reference						Reference	
North European					3.34	(4.93)					3.74	(5.84)
South European					-11.37	(15.51)					-9.89	(16.03)
East European					3.99	(10.41)					3.91	(10.90)
other					-2.24	(9.74)					4.27	(11.11)
Subject's Father's Ethnicity												
American							Reference				Reference	
North European							1.31	(4.93)			-0.78	(5.81)
South European							3.54	(12.77)			-1.33	(13.27)
East European							2.39	(11.25)			1.62	(11.70)
other							-14.61	(9.34)			-16.63	(10.93)
Subject's Birthplace												
Mid Atlantic									3.15	(6.33)	3.21	(6.41)
East North Central									Reference		Reference	
East South Central									-10.75	(7.55)	-9.47	(7.74)
West North Central									-5.20	(6.72)	-5.92	(6.71)
West South Central									3.28	(9.45)	4.10	(9.62)
Mountain									19.24*	(9.90)	18.98*	(10.07)
New England									1.80	(8.70)	1.35	(8.73)
Pacific									-3.80	(6.43)	-2.55	(6.47)
South Atlantic									-1.25	(6.56)	-0.60	(6.67)
Intercept	1,626.99***	(4.68)	1,624.78***	(4.99)	1,623.59***	(5.97)	1,624.97***	(5.77)	1,627.39***	(5.78)	1,624.60***	(7.28)
Observations	1148		1148		1148		1148		1148		1148	
Adjusted R^2	0.01		0.01		0.01		0.01		0.01		0.01	
F-Statistic	3.292		2.388		1.903		1.928		2.089		1.531	

Note: results are given in millimeters. Robust standard errors in parenthesis. * Significant at the 10% level ** Significant at the 5% level *** Significant at the 1% level

Source: ANSUR database

Table 3.4: Height of U.S. Born White Male Soldiers, Aged Between 20 and 43

Dependent Variable: Stature Variable	Model 1	(Standard Error)	Model 2	(Standard Error)	Model 3	(Standard Error)	Model 4	(Standard Error)	Model 5	(Standard Error)	Model 6	(Standard Error)
Birth Cohort												
1945 - 1949	-6.76	(7.92)	-6.80	(7.93)	-7.45	(7.88)	-5.60	(7.97)	-6.79	(7.88)	-6.16	(7.89)
1950 - 1954	2.74	(6.84)	2.57	(6.85)	1.06	(6.86)	2.75	(6.82)	2.88	(6.85)	2.21	(6.85)
1955 - 1959	Reference		Reference		Reference		Reference		Reference		Reference	
1960 - 1964	4.24	(5.61)	4.17	(5.63)	4.24	(5.65)	4.32	(5.62)	4.30	(5.64)	4.62	(5.68)
1965 - 1969	-1.57	(5.44)	-1.53	(5.48)	-1.20	(5.49)	-1.49	(5.47)	-1.04	(5.47)	-0.66	(5.51)
Military Rank												
Commissioned Officer	8.98	(5.78)	8.86	(5.80)	8.52	(5.83)	9.50	(5.81)	9.81*	(5.81)	10.30*	(5.88)
Enlisted Personnel	Reference		Reference		Reference		Reference		Reference		Reference	
Subject's Ethnicity												
American			Reference		Reference		Reference				Reference	
North European			4.14	(3.91)	0.02	(4.38)	2.07	(4.48)			-0.03	(4.63)
South European			-4.09	(13.32)	-6.46	(14.37)	9.33	(16.46)			8.71	(18.17)
East European			-0.47	(12.28)	-1.80	(13.58)	9.03	(13.62)			9.43	(14.50)
other			15.53	(23.53)	6.24	(26.01)	-0.16	(24.34)			0.52	(26.02)
Subject's Mother's Ethnicity												
American					Reference						Reference	
North European					8.90**	(4.32)					9.84*	(5.26)
South European					7.44	(11.94)					8.06	(12.08)
East European					2.15	(9.61)					5.27	(10.34)
other					17.44	(10.90)					12.54	(12.08)
Subject's Father's Ethnicity												
American							Reference				0.00	(0.00)
North European							3.19	(4.41)			-3.38	(5.31)
South European							-16.28	(15.05)			-22.28	(15.63)
East European							-14.91	(11.11)			-23.03*	(12.33)
other							18.40**	(9.07)			8.48	(10.29)
Subject's Birthplace												
Mid Atlantic									2.01	(6.44)	2.60	(6.55)
East North Central									Reference		Reference	
East South Central									-4.97	(8.01)	-4.39	(8.10)
West North Central									9.45	(6.82)	7.14	(6.86)
West South Central									2.38	(7.28)	1.32	(7.39)
Mountain									1.90	(10.28)	0.84	(10.52)
New England									-4.83	(9.67)	-5.32	(9.84)
Pacific									8.41	(6.05)	7.21	(6.14)
South Atlantic									-1.87	(5.80)	-2.07	(5.87)
Intercept	1,762.32***	(4.63)	1,761.00***	(4.89)	1,757.14***	(5.37)	1,759.48***	(5.29)	1,760.39***	(6.04)	1,757.10***	(6.69)
Observations	1337		1337		1337		1337		1338		1338	
Adjusted R^2	0.00		-0.00		0.00		0.00		-0.00		0.00	
F-Statistic	1.238		0.871		1.084		1.222		1.036		1.021	

Note: results are given in millimeters. Robust standard errors in parenthesis. * Significant at the 10% level ** Significant at the 5% level *** Significant at the 1% level

Source: ANSUR database

Table 3.5: Height of U.S. Born Black Female Soldiers, Aged Between 20 and 43

Dependent Variable: Stature Variable	Model 1	(Standard Error)	Model 2	(Standard Error)	Model 3	(Standard Error)	Model 4	(Standard Error)	Model 5	(Standard Error)	Model 6	(Standard Error)
Birth Cohort												
1945 - 1949	12.88	(14.25)	13.04	(14.25)	12.22	(14.15)	13.01	(14.14)	13.02	(14.17)	12.60	(14.09)
1950 - 1954	6.06	(7.21)	6.13	(7.24)	6.15	(7.26)	5.76	(7.27)	5.69	(7.29)	5.53	(7.36)
1955 - 1959	Reference		Reference		Reference		Reference		Reference		Reference	
1960 – 1964	-1.37	(4.93)	-1.09	(4.94)	-0.99	(4.94)	-1.28	(4.95)	-1.64	(4.94)	-1.33	(4.96)
1965 – 1969	2.45	(4.91)	2.78	(4.93)	2.94	(4.92)	2.80	(4.94)	1.89	(4.93)	2.44	(4.95)
Military Rank												
Commissioned Officer	12.76*	(7.04)	12.28*	(7.05)	12.26*	(7.03)	11.62	(7.07)	13.26*	(7.12)	12.24*	(7.13)
Enlisted Personnel	Reference		Reference		Reference		Reference		Reference		Reference	
Subject's Ethnicity												
American			Reference		Reference		Reference				Reference	
African			4.72	(5.54)	-0.30	(12.65)	-1.59	(10.55)			-1.30	(14.65)
Latin America			-22.42*	(13.35)	-11.08	(22.47)	-32.70	(24.68)			-20.20	(29.23)
other			-2.99	(17.76)	-30.08	(27.34)	-24.93	(22.61)			-34.90	(29.17)
Subject's Mother's Ethnicity												
American					Reference						Reference	
African					5.18	(12.30)					-1.89	(12.88)
Latin America					-11.25	(18.91)					-20.54	(17.89)
other					27.19	(21.31)					12.13	(22.19)
Subject's Father's Ethnicity												
American							Reference				Reference	
African							8.83	(10.28)			9.51	(10.42)
Latin America							12.91	(21.34)			17.81	(19.73)
other							24.60	(15.18)			21.37	(15.67)
Subject's Birthplace												
Mid Atlantic									10.32*	(6.00)	10.18*	(6.07)
East North Central									4.23	(5.88)	3.89	(5.88)
East South Central									2.12	(5.40)	1.28	(5.44)
West North Central									12.15	(8.21)	11.20	(8.20)
West South Central									-3.06	(6.30)	-3.91	(6.36)
Mountain									-0.24	(22.92)	-2.60	(22.62)
New England									6.70	(16.39)	3.96	(16.78)
Pacific									8.86	(15.28)	6.72	(15.40)
South Atlantic									Reference		Reference	
Intercept	1,628.10***	(3.80)	1,624.09***	(6.35)	1,623.90***	(6.39)	1,621.54***	(6.45)	1,625.71***	(4.21)	1,620.41***	(6.67)
Observations	1141		1141		1141		1141		1141		1141	
Adjusted R^2	0.00		0.00		0.00		0.00		-0.00		-0.00	
F-Statistic	1.201		1.460		1.318		1.331		0.899		1.091	

Note: results are given in millimeters. Robust standard errors in parenthesis. * Significant at the 10% level ** Significant at the 5% level *** Significant at the 1% level

Source: ANSUR database

Table 3.6: Height of U.S. Born Black Male Soldiers, Aged Between 20 and 43

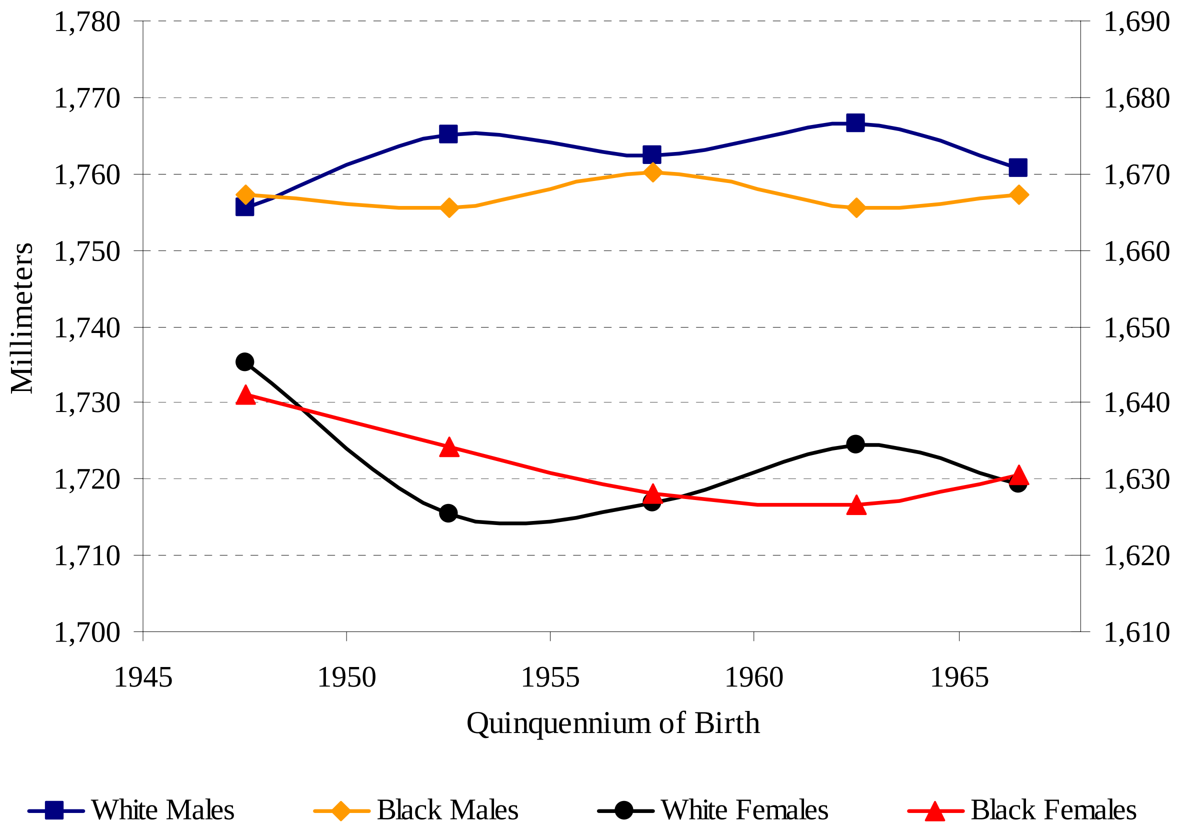
Dependent Variable: Stature Variable	Model 1	(Standard Error)	Model 2	(Standard Error)	Model 3	(Standard Error)	Model 4	(Standard Error)	Model 5	(Standard Error)	Model 6	(Standard Error)
Birth Cohort												
1945 - 1949	-2.89	(10.85)	-2.02	(10.86)	-1.44	(10.89)	-1.94	(10.88)	-2.63	(11.04)	-1.23	(11.10)
1950 - 1954	-4.60	(7.48)	-4.15	(7.48)	-4.59	(7.54)	-4.06	(7.52)	-3.15	(7.52)	-2.98	(7.62)
1955 - 1959	Reference		Reference		Reference		Reference		Reference		Reference	
1960 - 1964	-4.60	(5.53)	-4.09	(5.55)	-4.07	(5.55)	-4.12	(5.57)	-5.21	(5.55)	-4.60	(5.60)
1965 - 1969	-2.98	(5.41)	-2.67	(5.41)	-2.74	(5.41)	-2.73	(5.42)	-4.45	(5.49)	-4.21	(5.49)
Military Rank												
Commissioned Officer	15.39	(10.78)	15.53	(10.78)	15.65	(10.80)	15.48	(10.79)	15.82	(10.77)	16.06	(10.80)
Enlisted Personnel	Reference		Reference		Reference		Reference		Reference		Reference	
Subject's Ethnicity												
American			Reference		Reference		Reference				Reference	
African			-6.78	(4.74)	22.31	(16.48)	-11.67	(16.40)			11.98	(21.32)
Latin America			54.07**	(23.88)	81.54***	(30.81)	62.12**	(29.87)			79.68**	(31.95)
other			1.51	(26.26)	17.12	(25.33)	-3.59	(33.25)			-3.90	(35.76)
Subject's Mother's Ethnicity												
American					Reference						Reference	
African					-29.49*	(16.35)					-27.46	(16.87)
Latin America					-27.71	(19.83)					-20.22	(24.71)
other					-21.11	(18.07)					-12.12	(19.99)
Subject's Father's Ethnicity												
American							Reference				Reference	
African							4.97	(16.77)			8.27	(18.66)
Latin America							-8.03	(18.77)			-3.68	(21.26)
other							5.14	(21.09)			6.48	(22.27)
Subject's Birthplace												
Mid Atlantic									5.42	(6.75)	5.60	(6.83)
East North Central									16.02***	(5.88)	15.96***	(5.88)
East South Central									-1.65	(5.47)	-1.69	(5.51)
West North Central									-7.10	(12.25)	-6.83	(12.36)
West South Central									-2.79	(6.84)	-2.88	(6.90)
Mountain									54.84*	(28.84)	55.21*	(29.44)
New England									43.09**	(19.62)	42.63**	(20.42)
Pacific									-8.54	(11.05)	-9.20	(11.17)
South Atlantic									Reference		Reference	
Intercept	1,760.23***	(4.38)	1,764.98***	(5.72)	1,765.20***	(5.74)	1,764.97***	(5.82)	1,758.55***	(4.77)	1,763.52***	(6.14)
Observations	1235		1235		1235		1235		1235		1235	
Adjusted R^2	-0.00		-0.00		-0.00		-0.00		0.01		0.00	
F-Statistic	0.544		1.428		1.325		1.096		1.689		1.581	

Note: results are given in millimeters. Robust standard errors in parenthesis. * Significant at the 10% level ** Significant at the 5% level *** Significant at the 1% level

Source: ANSUR database

The estimated coefficient for males indicates a similar effect, but it turns out to be significant only in some specifications of the white males. The effect appears to be larger among the blacks (1.5 – 1.6 cm), but remains statistically insignificant as there is only a small number of observations available (N=40).

Figure 3.3: Time Trend in Height of U.S. Army Personnel



Sources: Table 3.3, Table 3.4, Table 3.5 and Table 3.6
Note: Male heights are measured on left scale, female heights on right scale

The results of the ethnical information included in the regression do not exhibit a clear pattern. For whites, Northern European ancestry appears to be associated with a slim advantage (0.5 cm – 1.0 cm) in height over subjects that consider themselves as American. The coefficient for all ethnical controls (the subjects' own, its mother's and its father's ethnicity) shows a positive impact on stature. For white females, the effect of the subject's Northern European ethnicity is significant (in Model 2 only); so is the effect of a Northern European mother among white males. For females, Eastern European ethnicity also appears to be associated with taller stature compared to Americans, yet the estimate is not significant. The effect of the other ethnical groups used in the analysis of whites is inconclusive: The direction of the coefficient is changing in the different specification and the directions of the parents' ethnicity are opposed to the subjects' own ethnicity.

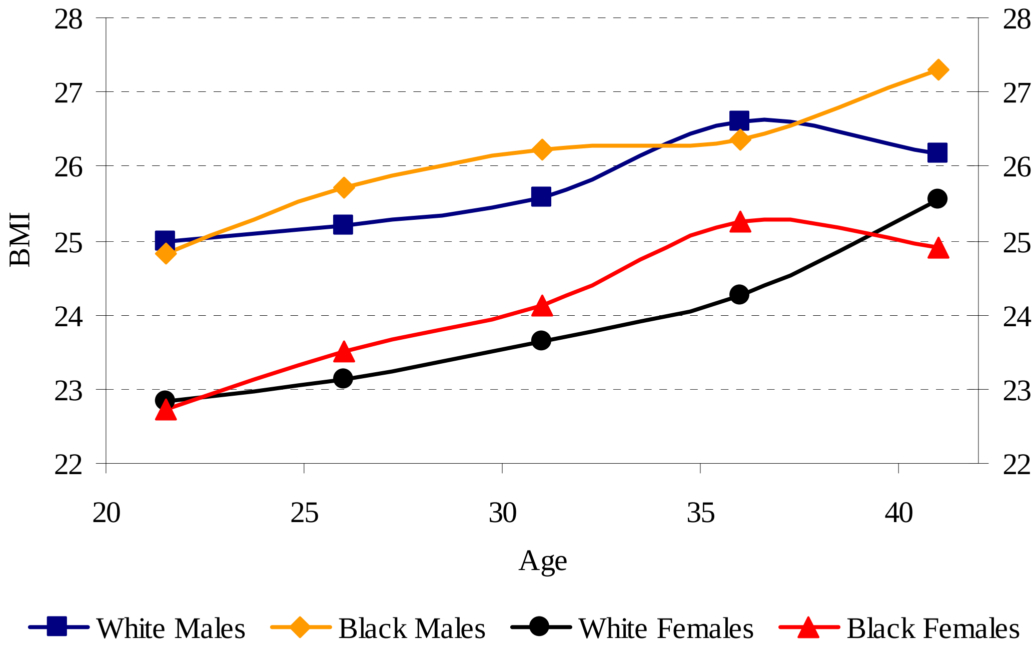
In the two subsets of black soldiers, the above mentioned problem of contradicting effects of ethnicity between the subject and its parents also prevails. Differences between American and African blacks (females and males) remain mostly insignificant. The number of observations pertaining to Latin American ethnicity is too small to credit the estimates with any reliability.

The results of specifications 5 and 6, which include information on the place of birth of the subjects, show a mixed pattern. White female soldiers from the Mountain region (see appendix I) are about 2 cm taller than the white reference group (East North Central). For white males, none of the spatial dummies turns out to be significant. For both, white females and males, the magnitude of the insignificant coefficients is 1 cm at the maximum. In the black female subset, the results are similar to the findings in the data pertaining to whites: Variation is rather small, and only black women from the Mid-Atlantic States are (at least marginally) significantly taller than the black reference group (South Atlantic). Greater differences exist among black males: soldiers born in one of the East North Central states are 1.6 cm taller than Southerners. The estimates for New England and the Mountain region remain questionable, as the number of observations is too small (N=5 and N=7, respectively). But within the eastern United States, a north-south gradient is noted for black male soldiers.

Body Mass Index of U.S. Military Personnel

The results in Table 3.7 and Figure 3.4 show that BMI increases with age as the majority of the coefficients are highly significant. While the general pattern is monotonic, there are two deviations among the older cohorts: body mass of white males aged 34 to 38 is higher than among those five years older, a similar pattern can be observed for black females (even though the coefficients for those 39 and older are not significantly different from the reference group).

Figure 3.4: Body Mass Index of U.S. Army Personnel



Source: Estimates for Model 1 based on ANSUR database

Commissioned officers appear to be a little less heavy than enlisted personal (except for white males), but the effect is significant for white females only. Ethnicity of the subjects and his/ her parents does not affect BMI in a significant way among the whites, and in addition to the insignificance, the magnitude of the estimated coefficients is small with less than 0.5 BMI points (about 1.5 kg for a male of 176.0 cm or 1.3 kg for a female of 163.0 cm). Among the blacks the influence is not precisely clear: While the results show that having a Latin American mother has a positive effect on BMI of black females of 1.6 BMI points, a Latin American father has a negative impact of -2.3 BMI points. Similarly, for black males the effect of being of African origin is almost completely offset by having a mother of African ethnicity. So apparently there is no clear impact of the ethnicity on the BMI among American soldiers.

Table 3.7: BMI of U.S. Army Personnel, Aged Between 20 and 43

Dependent Variable: BMI Variable	White Females		White Males		Black Females		Black Male	
Age Group								
39 to 43 years	1.78***	(0.54)	0.58	(0.38)	0.76	(0.64)	1.11**	(0.46)
34 to 38 years	0.62*	(0.33)	1.04***	(0.31)	1.18***	(0.31)	0.09	(0.36)
29 to 33 years	Reference		Reference		Reference		Reference	
24 to 28 years	-0.55**	(0.24)	-0.50**	(0.24)	-0.63***	(0.22)	-0.53**	(0.26)
20 to 23 years	-0.85***	(0.23)	-0.63***	(0.23)	-1.46***	(0.21)	-1.37***	(0.24)
Military Rank								
Commissioned Officer	-0.67***	(0.20)	0.08	(0.22)	-0.35	(0.28)	-0.08	(0.41)
Enlisted Personnel	Reference		Reference		Reference		Reference	
Subject's Ethnicity								
American	Reference		Reference		Reference		Reference	
North European	0.22	(0.20)	0.19	(0.21)				
South European	0.23	(0.72)	0.06	(0.85)				
East European	0.41	(0.53)	-0.10	(0.81)				
African					0.74	(0.54)	1.42	(1.14)
Latin American					0.55	(0.82)	-0.16	(2.00)
other	-0.19	(0.65)	-1.17	(1.20)	-0.76	(1.63)	-3.50*	(1.96)
Subject's Mother's Ethnicity								
American	Reference		Reference		Reference		Reference	
North European	-0.17	(0.26)	-0.01	(0.24)				
South European	-0.20	(0.60)	-0.34	(0.53)				
East European	-0.20	(0.40)	0.35	(0.50)				
African					-0.98**	(0.49)	-1.86**	(0.89)
Latin American					1.64***	(0.47)	0.31	(1.42)
other	-0.13	(0.51)	-0.57	(0.51)	0.75	(0.90)	-1.27	(1.16)
Subject's Father's Ethnicity								
American	0.00		0.00		Reference		Reference	
North European	0.35	(0.27)	-0.02	(0.24)				
South European	-0.34	(0.57)	0.51	(0.79)				
East European	0.02	(0.41)	0.03	(0.62)				
African					0.07	(0.50)	0.57	(1.11)
Latin American					-2.25***	(0.69)	-0.35	(1.45)
other	0.19	(0.44)	0.26	(0.43)	0.36	(0.62)	2.02	(1.47)
Subject's Birthplace								
Mid Atlantic	-0.13	(0.25)	0.37	(0.28)	0.28	(0.24)	-0.15	(0.31)
East North Central	Reference		Reference		0.16	(0.23)	-0.33	(0.26)
East South Central	0.73**	(0.36)	0.03	(0.34)	0.34	(0.23)	0.08	(0.26)
West North Central	0.13	(0.28)	0.33	(0.31)	0.44	(0.44)	-0.44	(0.49)
West South Central	0.01	(0.37)	0.40	(0.32)	-0.02		0.19	(0.28)
Mountain	-0.15	(0.39)	-0.66*	(0.37)	0.71	(0.89)	-0.63	(0.62)
New England	-0.35	(0.34)	0.98**	(0.38)	-0.01	(0.61)	-0.16	(0.76)
Pacific	0.17	(0.29)	0.52*	(0.27)	0.36	(0.49)	0.86	(0.67)
South Atlantic	-0.73***	(0.27)	0.49**	(0.25)	Reference		Reference	
Intercept	23.55***	(0.30)	25.25***	(0.27)	24.10***	(0.29)	26.08***	(0.27)
Observations	1148		1338		1141		1235	
Adjusted R^2	0.06		0.04		0.09		0.05	
F-Statistic	3.761		3.320		7.024		4.370	

Note: results are given in kg/ m². Robust standard errors in parenthesis.
* Significant at the 10% level ** Significant at the 5% level *** Significant at the 1% level

Source: ANSUR database

Some spatial effects are apparent in the regressions, yet there prevails no meaningful pattern in the results. White female soldiers born in the South Atlantic states are 0.73 BMI points lighter than those born in the East North Central Division. Simultaneously, white women born in the East South Central Division are another 0.73 BMI points heavier than those born just north of them. Among the white males, soldiers born in New England, the Pacific region or the South Atlantic states are heavier (by 1.0, 0.5 and 0.5 BMI points, respectively) than the ones born in the East North Central Division. Soldiers born in the Mountain states are another 0.66 BMI points lighter.

In both of the black subsets, none of the regional estimates show up to be significant, and they also do not reveal a common pattern for females and males. Also, the magnitude of most of the birthplace coefficients is rather small.

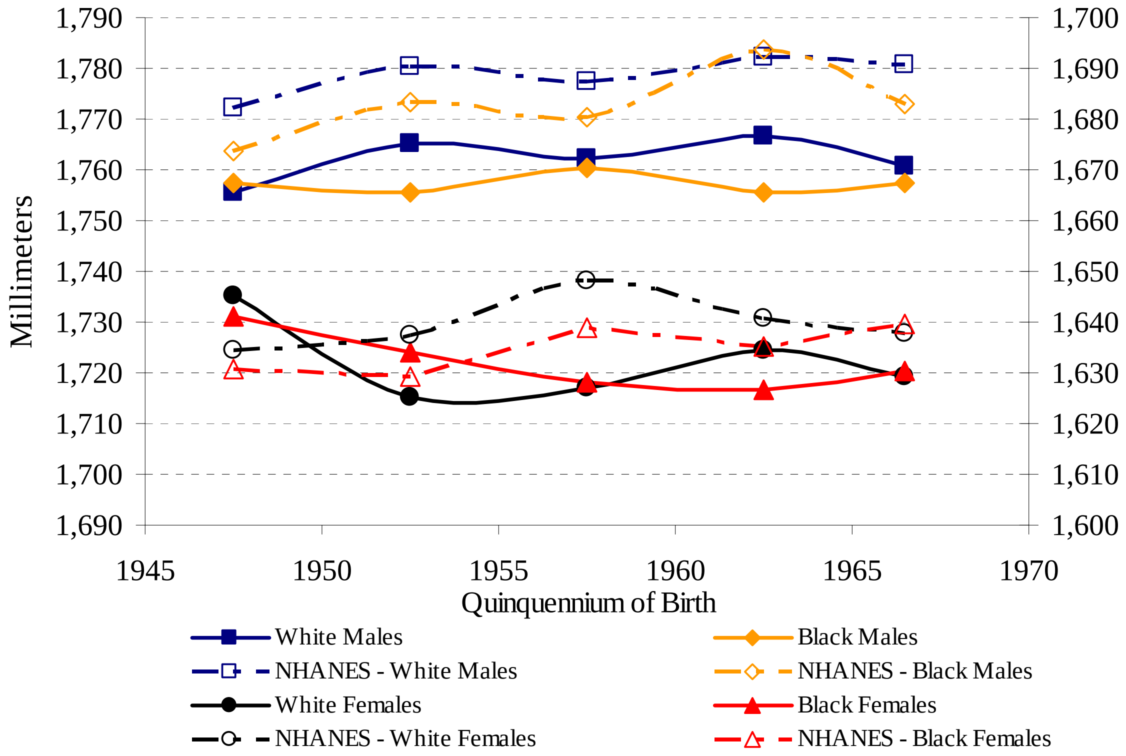
Overall, the impact of the birth place on the body mass of the subjects is rather negligible.

Discussion

The analysis of the ANSUR dataset shows that heights of U.S. Army personnel tended to stagnate during the 1950s and 1960s with some variation among the races and genders, but there is no indication of an increasing height. This result does not significantly change the results found in Komlos (2006) even though the sample size is twice as large. A height gradient by socio-economic status, proxied by military rank, is noted. Ethnicity of both, the subject and its parent, appears to have only a marginal and mostly insignificant impact. There is an indication that subjects who identify themselves as of Northern European Ancestry are slightly taller than those who classify themselves as American. This is also the only result for which the influence of the subjects' and its parents' ethnicity is consistent. In most of the other cases, the results remain either insignificant or contradictory with respect to the distinction between direct and parental influence. Since trends in height are typically analyzed by race without controlling for the exact ethnicity, this results validates the usual method of analysis. Differences in the ethnic composition of a dataset apparently do not significantly influence the levels and trends in height.

For validation of the results obtained, the estimated heights of the U.S. army personnel are compared to the estimates of the NHANES survey (Figure 3.5). The main finding corroborates trends found in the NHANES data set, in spite of the fact that the onset of the stagnation in heights is not identical (Komlos and Lauderdale 2007a; Komlos and Baur 2004). In comparison to NHANES data, there are some differences in the level of height, with the U.S. army personnel being somewhat shorter (about 1.4 - 1.7 on average cm among males and a little less among the females). This is an indication that the ANSUR database describes subjects that stem from a poorer or less educated segment of the U.S. society with a lower than average standard of living. There are also some differences between the ANSUR and the NHANES data regarding quinquennial variations. But the stagnation of height in the 1960s is

Figure 3.5: Comparison of Military and NHANES Heights



Source: Model 1 in Table 3.3, Table 3.4, Table 3.5 and Table 3.6, NHANES: Komlos and Lauderdale 2007a
Note: Male Heights are measured on left scale, Female Heights on right scale.

in general supported by both datasets. Thus, the ANSUR data supports the conclusion reached in Komlos and Lauderdale (2007a) that U.S. heights tended to begin to stagnate shortly after World War II. This stagnation is quite puzzling considering the high average per capita income as increases in income did not translate into physical growth, leading to a relative decline in comparison to other western populations. Potential explanations for this phenomenon include the large social inequality in the U.S., inefficiencies in U.S. health care system, the less comprehensive social safety net (including health insurance) and larger spatial differences in the U.S. (Komlos and Baur 2004, Komlos and Lauderdale 2007a).

With respect to BMI, no congruent ethnic or spatial effects can be observed. There is a clear age effect that shows an increase in body mass among older military personnel. This confirms patterns found among the civilian population (Flegal et al 2002, Komlos and Baur 2004, Komlos and Lauderdale 2007a). A comparison of the levels and prevalence of obesity between the U.S. Army personnel and the civilian population shows that the military personnel is less affected by the obesity epidemic; but considering the physical requirements of the military routine, this is not surprising.

Conclusion

Analysis of data of the physical stature and ethnicity of U.S. Army soldiers shows that physical stature stagnated in the early decades of the second half of the 20th century. The stagnation was not influenced by changes in the ethnical composition of the data available for analysis, as neither the subjects' own ethnicity not his parents' ethnicity has a significant impact on the subjects' physical stature. Spatial differences between census divisions in the United States could not be observed among the U.S. Army personnel. Thus, changes in the ethnical and spatial composition of the data are unlikely to account for the relative decline in stature observed in the U.S. civilian population. The lack of influence of ethnicity and place of birth can also be observed with respect to BMI.

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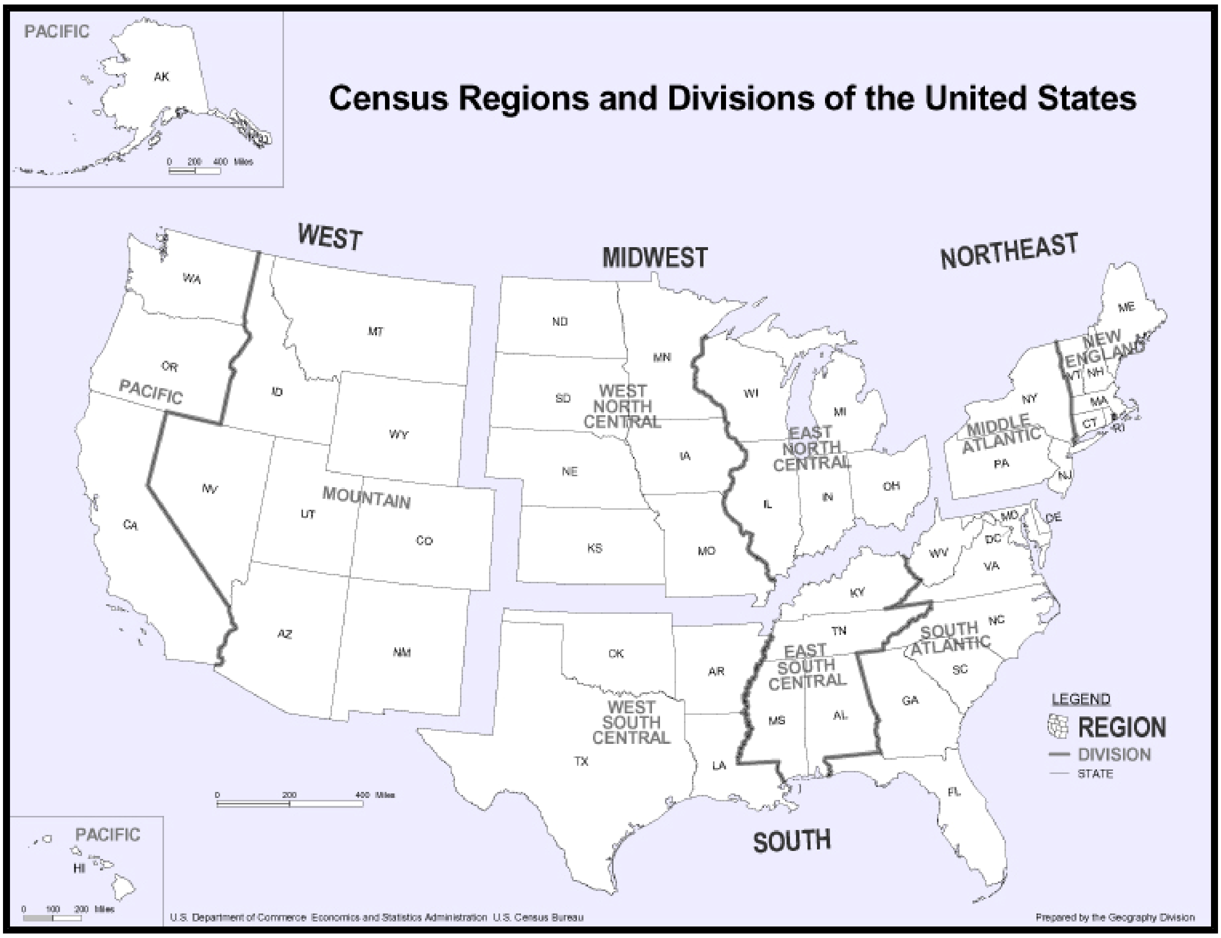
Appendix I: Regional Division of the United States

Figure 3.6: Census Regions and Divisions of the United States



Source: U.S. Bureau of the Census

PART IV: Taller – Healthier – More Equal? The Biological Standard of Living in Switzerland in the Second Half of the 20th Century

Abstract

This paper analyzes the trends in physical stature and body mass of the Swiss population born between 1955 and 1985, based on data collected in the "Living in Switzerland Survey" (Swiss Household Panel) of 2004. Aside from the time trend, we investigate the impact of educational and marital status as well as spatial effects on height and BMI. The results obtained are in line with expectations and the experiences of previous studies: Average height increased during the second half of the 20th century for both women and men, better educated individuals are taller than their lower educated counterparts, divorced men are shorter than married men and urban populations enjoy a height advantage over rural ones.

We also compare the level and the trend in height to other postindustrial populations to identify key causes of physical growth and conclude that the quality of the health care systems and equality in access to it seem to have a greater impact than other redistributive aspects of a welfare state. The relatively low level of inequality in health led to height levels in Switzerland that are similar to those obtained in the Scandinavian social-democratic welfare states. Other measures such as income inequality do not serve as explanations for the average stature of the Swiss population.

Introduction

Physical attributes, such as height, weight and body mass, are powerful indicators of well-being (Komlos and Snowden 2006, Steckel 1995, Fogel 1994). They are not the result of chance, but are, at least in part, influenced by individual choices such as diet and nutritional intake, work effort, as well as by external factors such as the disease environment. Height and body mass reflect the nutritional status of an individual – as a cumulative function of the net nutritional status during childhood and adolescence in case of height and as indicator of the more recent situation in case of body mass (Komlos 1989). In this paper we estimate the trends in adult height and body mass of the Swiss population in order to assess their nutritional status and biological well-being, determine socio-economic key influences on the height attained and compare our results to the findings of other research pertaining to the population of other western countries.

While about 200 years ago, the North American population towered over all European countries by several centimeters (Steckel 2002), this situation has reversed in the course of the 20th century. The most advanced countries in Europe, such as Norway, Sweden, the Netherlands, the UK and Germany have overtaken the U.S. in terms of height (Sunder 2003, Fredricks et al. 2000, Komlos and Kriwy 2002, Cavelaars et al. 2000), as the secular trend in the average height of the U.S. population has stagnated among those born circa 1955-1975 (Komlos and Baur 2003, Komlos and Lauderdale 2006, Komlos 2006). This 'reversal of fortune' measured by the height gradients remains puzzling as the U.S. population enjoyed strong growth in per capita income and also supports the most expensive health care system of the world (WHO 2000). Potential explanations offered to resolve this puzzle include the different levels of inequality among the different welfare systems as well as differences in the way the health care systems work. Western European nations, especially those of with the tallest populations, such as the Scandinavian countries and the Netherlands, are known for their extensive redistributive systems and high levels of state expenditures in fields such as education, health care, social assistance and the like. Simultaneously, even though the overall health care expenditures are at a lower level in these states than in the U.S., these systems cover a broader range of the population with more extensive 'basic' services and thereby provide health care at a more universal level through state intervention.

Switzerland, in contrast to many other continental European states, is considered to have a less interventionist government. Its welfare system, commonly classified as Christian-Democratic, is less redistributive and its citizens have greater influence on policy making due to extensive elements of direct democracy such as general public referenda on proposed legislation. Switzerland is also one of the wealthiest nations in Europe with extremely high per capita income in terms of purchasing parity (Heston et al. 2006). Overall, Switzerland can be described as an intermediate system situated between the social-democratic Scandinavian countries and the liberal U.S. system. In light of this position, it is of great interest how the differences in the political structure and extent of the welfare state affect the biological well-being of the Swiss population.

Data

We analyze data from the 2004 wave (wave 6) of the Swiss Household Panel (SHP, http://www.swisspanel.ch), a survey based on telephone interviews gathering data on a broad range of social topics, including objective and subjective information on the interviewees (Budowski et al. 2001). The 2004 wave contains data on 8,067 people living in 5,375 households. It consists of two subsets: 4,413 people have taken part of the five previous waves as well (SHP_I), and 3,654 individuals were interviewed for the first time to make up for losses from the original sample due to deaths, migration, or unwillingness to answer. (SHP_II). The key information of interest here – stature and body mass – were reported in wave 6 for the first time. This enables us to pool both subsets of data, SHP_I and SHP_II, as we are unable to exploit the panel structure of the data in the first place. The data is further amended by 3,498 observations from the Statistics of Income and Living Conditions (SILC) survey collected by the Swiss Federal Office of Statistics. As the data from both the SHP and the SILC was collected in a coordinated effort (the sampling framework is and the majority of the questions are identical) it can be pooled for analysis. In order to ensure that the dataset is representative of the Swiss population, weights for the observations are included in the dataset.

We focus on individuals between the ages of 18 and 50 years (born in Switzerland between 1954 and 1986), as this is the period in life during which the stature is relatively stable. Prior to the age of 18, the growth process is not finished,[56] and after the age of 50 the process of shrinkage begins. While the end of the growth process is often placed at about 21, we want to include those near the attainment of final height to be able to locate the end of adolescent growth.[57] This leaves us with a total of 5,541 observations of stature; 2,537 of which are male and 3,004 are female. When analyzing the body mass, we lose another 10 (35) observations for men (women) as no weight was reported (Table 4.1).

The height and weight are reported in whole centimeters and kilograms. The data is self-reported and therefore may be biased. Subjects are known to misreport their height and weight in a manner that height is likely to be overstated while weight tends to be understated. A multitude of studies has been written comparing self-reported values with measured values among different populations, age groups and socio-economic groups (Jansen et al. 2006, Elgar et at. 2005, Brener et al. 2003, Spencer et al. 2002, Kuczmarski et al. 2001, Boström and Diderichsen 1997, Rowland 1990, Stewart et al. 1987, Palta et al. 1982, Himes and Roche 1982, Schlichting et al. 1981). Virtually all of these studies find that height was – on average – overstated. The magnitude varied between the different studies, and more detailed

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56 This holds in modern societies. Previous populations tended to grow slower and hence also later; for a detailed analysis of the acceleration effects, see Oppers (1963). The dataset also includes heights of younger people in the sample, but the number of observations is relatively small.

57 We limit the analysis of the stature to those subjects that reported a height larger than 140 cm and smaller than 250 cm for reasons of plausibility. For analysis of the body mass, we also excluded all observations without reported weight.

Table 4.1: Descriptive Statistics of the Sample.

	Mean	Standard deviation	N
Stature (self-reported)			
Female	166.07 cm	6.11 cm	3,004
Male	178.60 cm	6.70 cm	2,537
Weight (self-reported)			
Female	62.24 kg	10.92 kg	2,969
Male	78.25 kg	12.17 kg	2,527
Body Mass index[58] (self-reported)			
Female	22.57	3.74	2,969
Male	24.52	3.51	2,527
Stature (adjusted)			
Female	165.61 cm	5.37 cm	3,004
Male	177.25 cm	5.96 cm	2,537
Weight (adjusted)			
Female	63.23 kg	11.39 kg	2,969
Male	77.83 kg	12.40 kg	2,527
Body Mass index (adjusted)			
Female	23.04	3.91	2,969
Male	24.75	3.62	2,527
Age			
Female	35.13 yrs	9.35 yrs	3,004
Male	34.97 yrs	9.41 yrs	2,537

Source: Swiss Household Panel 2004

inspection revealed that people above the age of 50 tend to overstate by a larger extent than younger ones (Kuczmarski et al. 2001, Spencer et al. 2002) and that taller subjects overstate their height by a smaller extent that shorter ones – in fact, very tall people have also been observed to understate their height (Spencer et al. 2002, Boström and Diderichsen 1997, Schlichting et al. 1981). Less educated subjects and those who work in manual jobs overstate their height by a greater extent than more educated ones (Boström and Diderichsen 1997). However, the average difference between the self-reported and measured height is less than 1.5 cm for men, while women report their height even more accurately.

[58] The proper unit for the value of the BMI is kg/ m² – since this is generally not considered to be very useful, the unit is generally omitted.

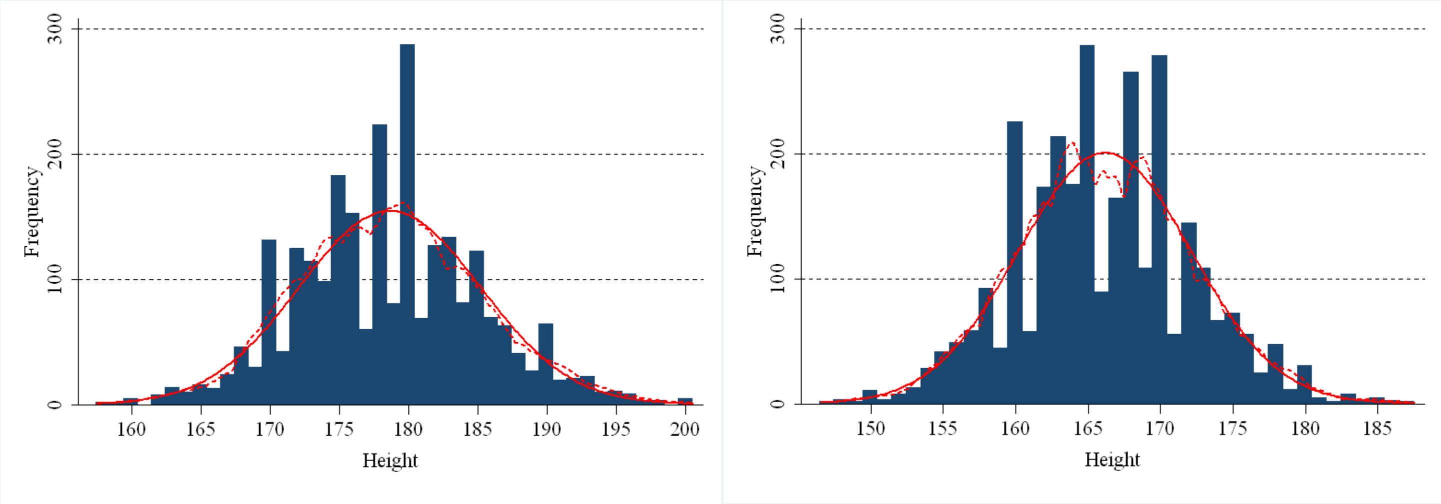
Facing the problem of misreported data, the preferred way of adjustment would be a factor or equation derived from a data set that pertains to the same population and includes both the measured and the self-reported data. Since such data is not available, adjusted heights were estimated based on the equations provided by Rowland (1990), which are based on more than 5'000 observations for both males and females from the NHANES II survey and controls for the age, the most-well known factor influencing the reporting bias. The respective adjustment equations are:

Male	*Height*	Adj. Height = 18.285 + 0.8865*Rep. Height + 0.05639*Age – 0.001*Age²
	Weight	Adj. Weight = –1.8754 + 1.0185*Rep. Weight
Female	*Height*	Adj. Height = 18.944 + 0.8745*Rep. Height + 0.1077*Age – 0.018*Age²
	Weight	Adj. Weight = –1.4534 + 1.0438*Rep. Weight – 0.00795*Age

As we are not able to include socio-economic differentials in our adjustment, the adjusted result only matter when comparing the attained level of height to the height of other populations.

Furthermore, a visual inspection of the histogram in Figure 2.8 shows that there is a considerable amount of heaping at convenient numbers such as 175 cm and 180 cm for the male subset and 160 cm, 165 cm and 170 cm for the female subset. However, such heaping will most likely not introduce any systematic bias into the data, as the upward and downward rounding should cancel each other out (Komlos 2004).

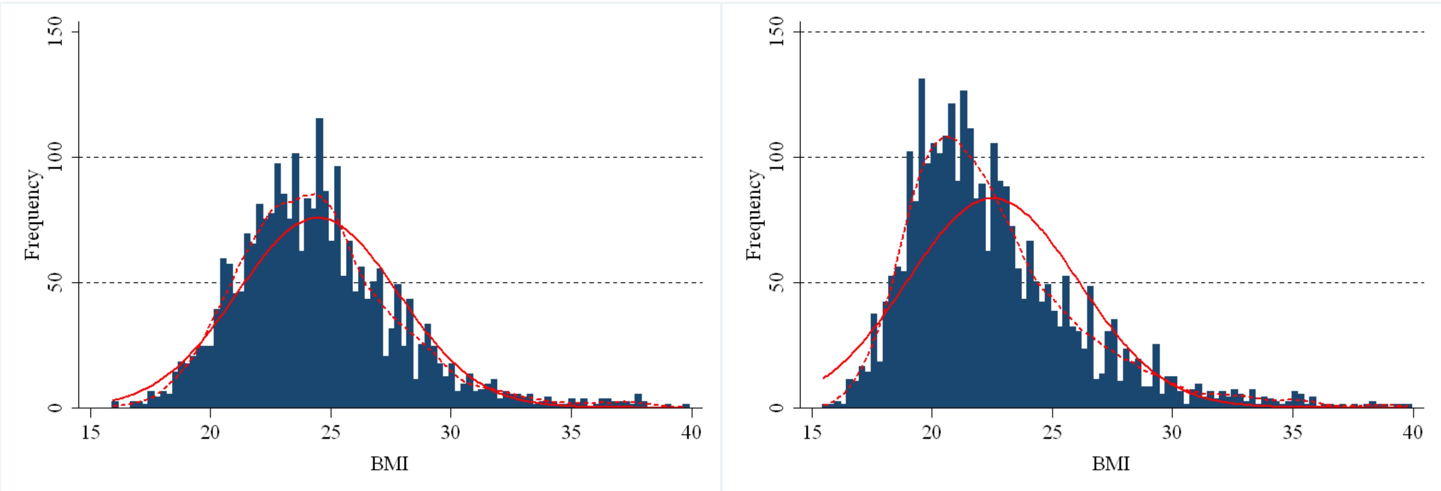
Figure 4.1: Histogram of Self-Reported Height Distribution (cm) for Swiss-born Men (Left) and Women (Right), Subjects Aged Between 18 and 50



Source: Swiss Household Panel 2004

The distribution of the body mass is right-skewed (Figure 4.2), which is a common observation though to different extents. The skewness coefficient of the distribution of the self-reported BMI as well as the adjusted BMI is 1.4 (1.7) for men (women), which is roughly in line with data pertaining to the U.S. population (Penman and Johnson 2006, Helmchen and Henderson 2004).

Figure 4.2: Histogram of Self-Reported BMI Distribution (kg/ m²) for Swiss-born Men (Left) and Women (Right), Subjects Aged Between 18 and 50



Source: Swiss Household Panel 2004

Table 4.2 shows several socio-economic characteristics of the sample. The educational status of an individual is of interest since we have no data on the socio-economic status of the individual's parents. As the attained height reflects the nutritional status and biological standard of living during childhood, prior to the time that the individual is self-sufficient, it is strongly influenced by the economic situation of its parents. The parents also determine to a large extent the amount of investment in their children's human capital. Thus, the educational status of an adult can serve as a reasonable proxy for the economic situation of the household during their childhood and adolescence and controlling for it is therefore important.

Table 4.2: Socio-Economic Characteristics of the Sample

Birth Cohort	Total	Male	Female
1981 - 1986	16.01	16.72	15.40
1976 - 1980	11.35	11.21	11.47
1971 - 1975	15.41	15.30	15.50
1966 - 1970	15.59	15.09	16.01
1961 - 1965	18.51	18.82	18.24
1954 - 1960	23.14	22.85	23.39
Educational Status (highest level completed)			
None	1.01	0.89	1.11
Compulsory school, one year of commerce school, domestic science course, general training school	13.36	10.13	16.10
Apprenticeship, full time vocational school	48.45	46.19	50.35
Maturity (high school)	10.67	8.56	12.45
Vocational high education, technical or vocational school	9.51	12.64	6.85
Vocational high school, university, higher specialized school	16.74	21.34	12.86
No answer	0.26	0.25	0.28
Marital Status			
Unmarried	43.06	46.00	40.58
Married	49.23	47.60	50.60
Divorced or seperated	7.01	6.01	7.86
Widowed	0.64	0.26	0.96
Type of Community of Residence			
Centers, suburban and urban periphery	67.72	67.05	68.29
Rural commuters, mixed agricultural and peripheral agricultural	15.97	16.35	15.65
Wealthy Community	3.19	3.05	3.30
Tourist Community	2.72	3.04	2.46
Industrial Community	10.21	10.34	10.10
Region of Residence			
Lake Geneva	16.17	16.69	15.72
Espace Mittelland	25.04	25.21	24.89
Zurich Region	13.69	12.86	14.39
Northwestern Switzerland	16.82	16.64	16.98
Eastern Switzerland	14.32	14.95	13.79
Central Switzerland	10.37	10.12	10.59
Ticino	3.59	3.53	3.64

Source: Swiss Household Panel 2004

The type of community of residence[59] or the region of residence are not necessarily determinates of height and BMI, since the individual might have moved there just recently. But lacking better information, we use these variables as the best available proxy for the type of community and region in which the individual grew up. The distinction between urban and rural population has been well documented in the anthropometric literature: Up to the turn of the 20th century the former were significantly shorter than the latter as cities tended to have a much less favorable disease environment than rural areas. Hygiene was rather bad as running water was still uncommon in the 19th century. Hence, cities provided a breeding pool for all kinds of diseases, leading to sickness and to higher claims on the nutritional intake, thereby reducing the net nutritional status. Moreover, prior to effective cooling mechanisms, the supply of cities with protein-rich food, such as milk, dairy products and meat, was scarce. This situation changed in the early 20th century, and eventually the proximity to medical care within the cities reversed the former pattern, leaving those born in the countryside shorter than their urban counterparts.

Findings

For our analysis, we use both, the self-reported data on stature and BMI as well as the data that was obtained after adjusting for errors in self-reporting. As we will show later, the adjustment affects, in the main, only the estimated constant. Hence we will present the results from the original data first, and then show the differences to the results from analyzing the adjusted data.

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[59] The coding of community types follows the typological classification of Switzerland established by Joye et al. (1988) and refined by Schuler and Joye (2004).

Stature

First, we estimate a basic time trend by regressing the stature of both, the male and the female population on quinquennial dummy variables (Model 1). In Model 2, we add control variables for the highest achieved level of education (the categorization of the controls corresponds to the categories shown in Table 4.2). Thereafter, we add marital status (Model 3), and controls for the type of the community of residence (Model 4). Finally we add control variables for spatial effects within Switzerland.

The regression results of the male subset show a clearly increasing trend with respect to the birth cohorts up to those born in 1971-1975 who are about 2.0 – 2.2 cm taller than those born 15 years earlier. The secular trend ceased to those born 1976-1980. Those born 1980-1984 might still have been growing and hence their height is smaller. Furthermore, the educational status exhibits the expected pattern, showing that people with higher levels of education are taller. While there are no significant difference among the groups with less than a high school diploma, high school graduates are 1.2 cm taller than those who ended their education with a higher job training (that is, either a vocational high education or a education at a technical or vocational school). Subject that have obtained a college degree are 1.5 – 1.6 cm taller than those without a high school diploma.

Unmarried men are significantly shorter than married ones; yet one has to take into account that the correlation between the youngest birth cohort (born 1981 – 1986, so aged 18 – 23) and the status of not yet being married is relatively high (the correlation coefficient is 0.49). But the difference in the magnitude of the coefficients – introducing the control variable of the marital status reduces the birth cohort effect for the youngest cohort by just 0.27 cm, while unmarried men are 0.8 cm shorter than those married – shows that unmarried men are clearly shorter than married one, and the effect goes well beyond the potential influence of unmarried

Table 4.3: Height of Swiss Males, Aged 18 - 50.

Dependent Variable: Stature Variable	Model 1	(Standard Error)	Model 2	(Standard Error)	Model 3	(Standard Error)	Model 4	(Standard Error)	Model 5	(Standard Error)
Birth Cohort										
1981 – 1986	-0.86**	(0.41)	-0.41	(0.43)	-0.65	(0.46)	-0.65	(0.46)	-0.64	(0.46)
1976 – 1980	0.09	(0.43)	0.10	(0.43)	-0.04	(0.43)	-0.04	(0.43)	-0.05	(0.43)
1971 - 1975	Ref.		Ref.		Ref.		Ref.		Ref.	
1966 - 1970	-0.55	(0.38)	-0.44	(0.38)	-0.36	(0.38)	-0.35	(0.38)	-0.36	(0.38)
1961 - 1965	-1.31***	(0.36)	-1.17***	(0.36)	-1.05***	(0.37)	-1.05***	(0.38)	-1.07***	(0.37)
1954 - 1960	-2.01***	(0.35)	-1.81***	(0.35)	-1.67***	(0.37)	-1.66***	(0.37)	-1.67***	(0.37)
Education										
None			-2.31	(1.41)	-2.31	(1.41)	-2.28	(1.42)	-2.20	(1.44)
Compulsory School			-1.15***	(0.44)	-1.08**	(0.45)	-1.07**	(0.45)	-1.04**	(0.45)
Apprenticeship			-0.45	(0.37)	-0.39	(0.37)	-0.36	(0.37)	-0.36	(0.37)
Higher Job Training			Ref.		Ref.		Ref.		Ref.	
High School Diploma			0.03	(0.44)	0.07	(0.44)	0.08	(0.45)	0.10	(0.45)
College Degree			0.79*	(0.42)	0.78*	(0.42)	0.77*	(0.42)	0.79*	(0.42)
No Answer			-0.39	(1.37)	-0.32	(1.38)	-0.28	(1.38)	-0.17	(1.41)
Marital Status										
unmarried					0.42	(0.28)	0.40	(0.29)	0.36	(0.29)
married					Ref.		Ref.		Ref.	
divorced					-0.23	(0.38)	-0.25	(0.38)	-0.28	(0.38)
widowed					0.68	(1.58)	0.66	(1.57)	0.80	(1.65)
Type of Community of Residence										
Urban							Ref.		Ref.	
Rural							-0.19	(0.28)	-0.16	(0.29)
Wealthy Community							0.12	(0.57)	0.07	(0.57)
Tourist Community							-0.08	(0.69)	0.05	(0.69)
Industrial Community							-0.09	(0.35)	-0.05	(0.35)
Region of Residence										
Lake Geneva									-0.39	(0.37)
Espace Mittelland									-0.56*	(0.32)
Zurich Region									Ref.	
Northwestern									-0.19	(0.37)
Eastern									-0.31	(0.39)
Central									0.12	(0.38)
Ticino									-1.43**	(0.59)
Intercept	166.59***	(0.29)	166.70***	(0.42)	166.48***	(0.45)	166.51***	(0.46)	166.83***	(0.50)
Adjusted R^2	0.02		0.03		0.03		0.03		0.03	
F	10.662		7.615		6.380		5.052		4.190	

Source: SHP 2004. Note: results are given in centimeters. * Significant at the 10% level, ** Significant at the 5% level, *** Significant at the 1% level.

Table 4.4: Height of Swiss Females, Aged 18 - 50

Dependent Variable: Stature Variable	Model 1	(Standard Error)	Model 2	(Standard Error)	Model 3	(Standard Error)	Model 4	(Standard Error)	Model 5	(Standard Error)
Birth Cohort										
1981 - 1986	-0.78*	(0.47)	-0.28	(0.50)	-0.56	(0.52)	-0.55	(0.52)	-0.54	(0.52)
1976 - 1980	0.14	(0.49)	0.15	(0.49)	-0.02	(0.50)	-0.01	(0.50)	-0.02	(0.49)
1971 - 1975	Ref.		Ref.		Ref.		Ref.		Ref.	
1966 - 1970	-0.56	(0.43)	-0.44	(0.43)	-0.35	(0.43)	-0.34	(0.44)	-0.35	(0.44)
1961 - 1965	-1.26***	(0.42)	-1.11***	(0.42)	-0.97**	(0.43)	-0.97**	(0.43)	-0.99**	(0.43)
1954 - 1960	-1.74***	(0.41)	-1.51***	(0.41)	-1.34***	(0.42)	-1.34***	(0.42)	-1.35***	(0.42)
Education										
None			-2.57	(1.61)	-2.56	(1.61)	-2.53	(1.62)	-2.44	(1.65)
Compulsory School			-1.29**	(0.51)	-1.21**	(0.51)	-1.19**	(0.51)	-1.17**	(0.51)
Apprenticeship			-0.51	(0.42)	-0.44	(0.42)	-0.41	(0.42)	-0.41	(0.43)
Higher Job Training			Ref.		Ref.		Ref.		Ref.	
High School Diploma			0.03	(0.51)	0.08	(0.51)	0.09	(0.51)	0.12	(0.51)
College Degree			0.90*	(0.48)	0.89*	(0.48)	0.88*	(0.48)	0.91*	(0.49)
No Answer			-0.42	(1.56)	-0.33	(1.57)	-0.29	(1.57)	-0.16	(1.60)
Marital Status										
unmarried					0.48	(0.32)	0.46	(0.33)	0.41	(0.33)
married					Ref.		Ref.		Ref.	
divorced					-0.26	(0.43)	-0.28	(0.43)	-0.32	(0.43)
widowed					0.79	(1.80)	0.77	(1.80)	0.93	(1.88)
Type of Community of Residence										
Urban							Ref.		Ref.	
Rural							-0.22	(0.32)	-0.19	(0.33)
Wealthy Community							0.13	(0.65)	0.07	(0.66)
Tourist Community							-0.08	(0.78)	0.07	(0.79)
Industrial Community							-0.11	(0.40)	-0.06	(0.40)
Region of Residence										
Lake Geneva									-0.45	(0.42)
Espace Mittelland									-0.64*	(0.37)
Zurich Region									Ref.	
Northwestern									-0.21	(0.42)
Eastern									-0.36	(0.44)
Central									0.14	(0.43)
Ticino									-1.64**	(0.68)
Intercept	166.97***	(0.33)	167.10***	(0.48)	166.85***	(0.51)	166.88***	(0.52)	167.24***	(0.57)
Adjusted R^2	0.01		0.02		0.02		0.02		0.02	
F	6.382		5.592		4.771		3.794		3.254	

Source: SHP 2004. Note: results are given in centimeters. * Significant at the 10% level, ** Significant at the 5% level, *** Significant at the 1% level.

youngsters. Divorced and widowed men are also shorter than married ones, but the coefficient is not significant.

Men of rural origin are about 1.0 cm shorter than their urban counterparts. Interestingly, those communities coded in the original data as wealthy communities[60] show no significant advantage, but here the number of observations (N=83) is rather small.

The results for the female sample are similar. Even though the time trend is less pronounced, and the increase over the period from 1954 to 1975 amounts to just 1.4 – 1.7 cm, the trend is relatively stable up to those born before 1980. The educational controls also show a similar pattern, leaving those with only compulsory schooling 1.2 cm shorter than those who received a higher vocational training. College graduates, on the other hand, are 0.9 cm taller than vocational school graduates.

Opposed to the results for males, women show no significant differences in stature by marital status. The "type of community" coefficients as well as the spatial control coefficients are insignificant and very small in magnitude; only females residing either the Espace Mittelland or Ticino are 0.6 cm and 1.6 cm shorter than those residing in Zurich, respectively.

After an adjustment to the heights in the Swiss Household Panel using the equations estimated by Rowland (1990), the results of virtually all coefficients pertaining to the male sample changed by no more than 0.2 cm. The estimated constant decreases by 1.3 cm to 1.4 cm compared to the unadjusted male data, depending on the specification of the model. The delta

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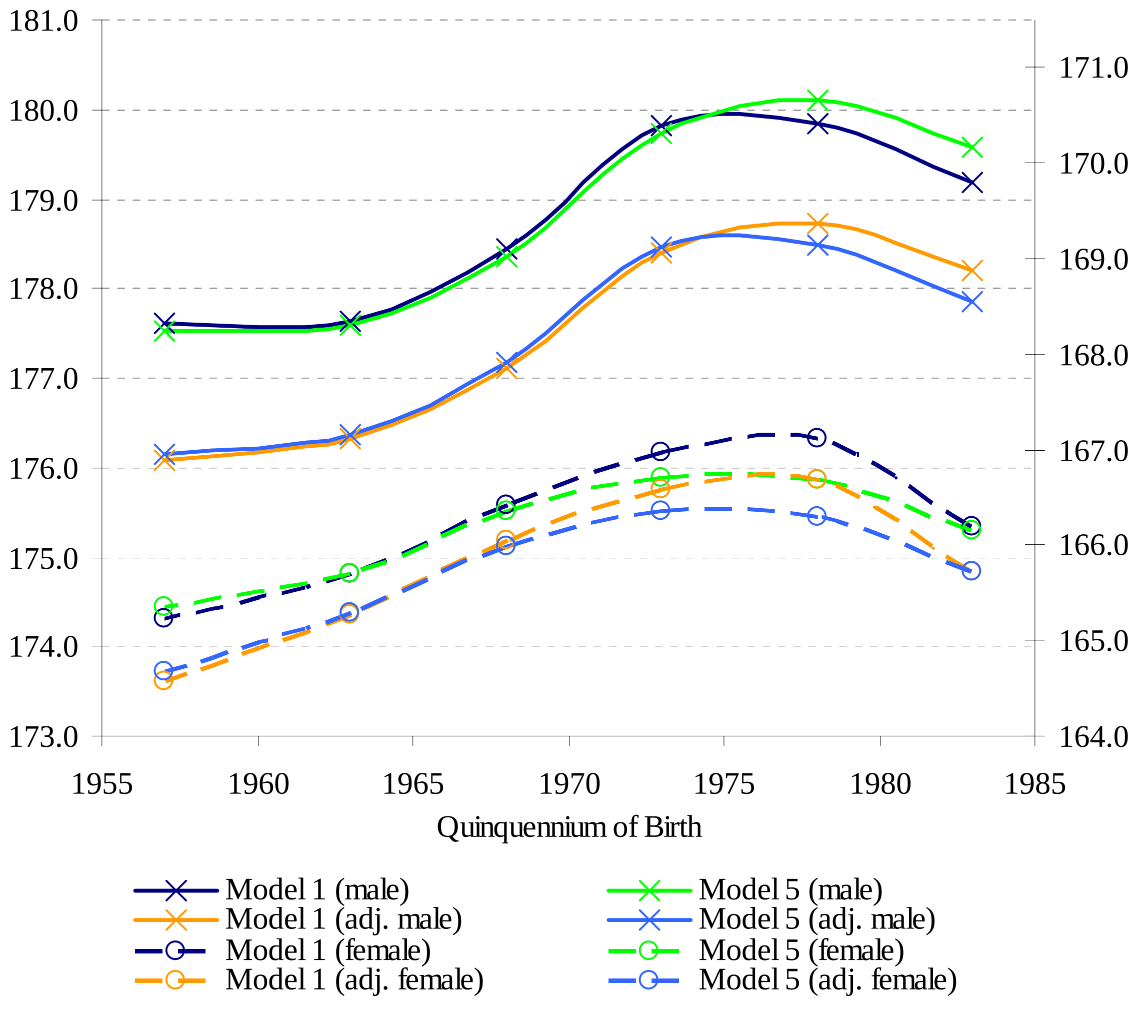
[60] The classification is based on a minimum real average tax income per natural person in that community. The threshold depends on whether the community is located in a metropolitan region (to reflect the different income and cost levels) and also takes into account the number of residents in order to mitigate the potential impact of outliers. See Schuler and Joye (2004) for details.

in the constant of the female regressions is smaller – all specifications differ by about 0.4 cm. However, in the female subset, the coefficient for the 1954 – 1960 birth cohort indicates that the adjusted height is about 0.3 cm shorter: Thus the secular trend among the female population might have been even more pronounced than the self-reported data suggests. The respective tables with the detailed results of the regression analysis of the adjusted data can be found in appendix I.

Figure 4.3: Height (cm) of Swiss Males (Left Scale) and Females (Right Scale)



Source: Table 4.3, Table 4.4, Table 4.10 and Table 4.11

We present the trends obtained in a graphical form in Figure 4.3, with the level of height adjusted for differences in educational level, marital status, type of community and region by using weighted averages of the estimated coefficients. For the sake of clarity we only show the specifications of Model 1 and Model 5 for both men and women.

The time trend calculated for the Swiss male population is in line with results obtained by Cavelaars et al. (2000), but on a slightly higher level. While Cavelaars et al. use unadjusted data from the Swiss Health Survey 1992/93 (which also uses self-reported heights) and their observations include birth cohorts from 1920 to 1970, they find a secular increase throughout the entire period considered. Starting with approx. 172.5 cm for males born in the 1920s, those born around 1970 reached a height of 178.0 cm. While the data from the Swiss Household Panel indicates a height level that is about 1.0 cm taller for the earliest birth cohorts (1954 – 1960) and about 0.4 cm for the birth cohorts of the 1960s (when weighted, this observation holds for all five specifications employed), the trend during which data for both samples are extant is similar. A comparison of the female population exhibits similar properties: While the self-reported heights of the birth cohorts 1954-1960 and 1961-1965 are approximately at the same level, the height of the 1966-1970 cohort in the SHP is about 0.7 cm higher than in the Cavelaars study.

Thus, Cavelaars et al. (2000) report an average increase of 0.63 cm (0.35 cm) per quinquennium for men (women) over their observation period and an increase of 2.7 cm (1.6 cm) for the period from 1950 – 1970. The increase estimated by the SHP data for the time period from the late 1950s to the early 1970s (as the time period of the datasets does not fully overlap and the categories were chosen differently, we cannot match the timing exactly) is 0.69 cm per quinquennium or 2.2 cm for the 15 years difference between the males from the 1954-1960 cohort and the 1971-1975 cohort. The female estimates from the SHP vary from 0.45 cm to 0.58 cm per quinquennium (1.35 cm – 1.74 cm in total over 15 years) and are hence slightly larger than the increments observed by Cavelaars et al. (2000).

We also refer to the results from Cavelaars et al. (2000) for an international comparison. As previously discussed, an international comparison should include an allowance for self-reporting bias. But when comparing our results to the Cavelaars et al. (2000) data, such an adjustment would be misleading as the Cavelaars results – with the exception of Germany– are also based on self-reported values (see Cavelaars et al. (2000) p. 414). They appropriately note that one cannot exclude the possibility that the amount of variation differed between countries, but conclude that this does not seem very plausible.

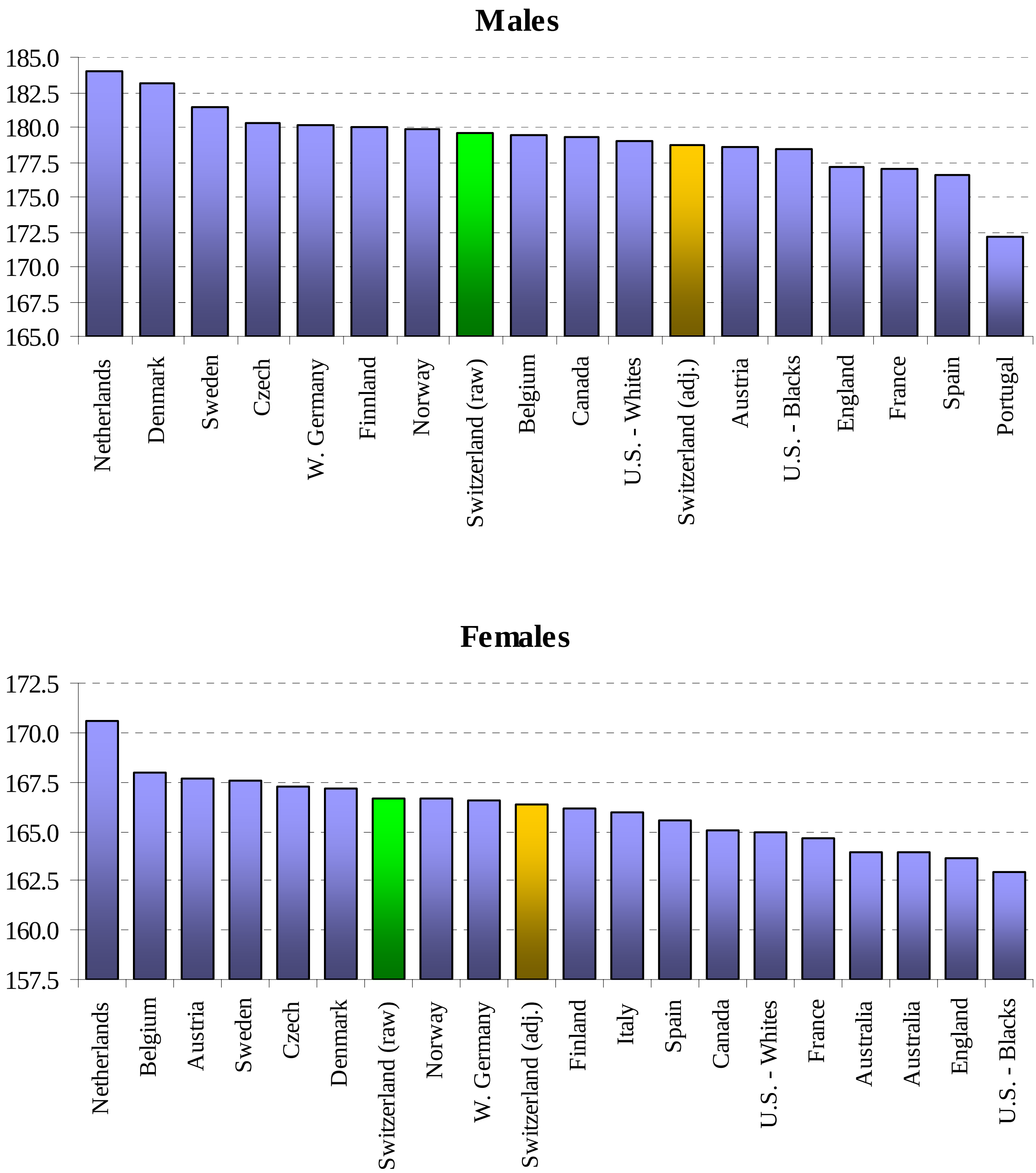
While Cavelaars et al. place the Swiss male population rather precisely between the population of Southern European countries such as France, Italy and Spain, who are roughly 2 – 5 cm shorter on average and Scandinavian Countries, the Netherlands and Germany, who are, with some more fluctuations taller by the same amount. Considering the differences in level between the Cavelaars results and the results obtained in this paper, the Swiss population might be closer to the top group of the Scandinavian countries than previously thought. The 180 cm (based on the reported data of the SHP) observed for those born in the first half of the 1970s in model 1 would imply equal height levels among the Swiss population and the Norwegian and Swedish one as reported by Cavelaars (2000) – still assuming that the reporting bias across countries does not differ significantly – leaving only the Dutch taller. This observation also holds for the Swiss females.

Considering more recent heights, especially at those born around 1980, we compare our findings with data collected by Komlos and Lauderdale (2007) in Figure 4.4. The Swiss population is relatively tall when the reported data is considered. While the Dutch population tower over all other by several centimeters, the Swiss men have about the same height as the Swedish, German and Norwegian males, and enjoy a slight advantage over the U.S. whites. However, when the adjusted height is considered, the ranking of Switzerland obviously worsens, but they still remain taller than European males such as the English, French and Spanish and U.S. Blacks.

The Swiss females report heights that are also in line with Norwegian and German females, but are shorter than females in the Netherlands or the Scandinavian countries other than

Finland. However, for the females the adjustment of the reported height changes the ranking less than it does for the males, placing the height values in the middle of the European countries we have data on and well above their north-American counterparts.

Figure 4.4 International Comparison of Recent Heights (cm)



Source: Komlos and Lauderdale 2007, Swiss Household Panel 2004

Body Mass Index

While height is an indicator of the nutritional status during the childhood and adolescence of an individual, body mass index (kg/ m²) is a proxy for the current nutritional status (Komlos 1989). Secondly, the trend in body mass is of interest when monitoring the prevalence of the obesity epidemic.

We use the same specifications as above to investigate determinants of BMI. For most of the control factors, we expect the opposite influence on BMI than on height. It has been observed that the BMI increases with age (we use age groups instead of birth cohorts as the body mass reflects the current level of nutritional status and remains subject to change throughout an individual's life) and that lower educational status correlates with increased BMI (Komlos and Baur 2004). Urban populations tend to be lighter than rural one.

In our sample, 5.6% (4.3%) of the male (female) population report body BMI values that classifies them as obese, i.e. having a BMI value of 30 or more.[61] This is a relatively low level of obesity – the U.S. National Health and Nutrition Examination Survey III report values between 15% and 20% (Flegal et al. 2002).

The regressions for both males and females show a clear tendency of the BMI to increase with age (Table 4.5, Table 4.6 and Figure 4.5). The magnitude of the age trend is similar for both genders, but the gradient is steeper among the males than among the females. The differences between the younger age groups are larger than it is between the older ones. A potential explanation is that the caloric intake remains unchanged after the growth process

[61] Using the adjusted values, these Figures change to 6.8% for men and 5.4% for women, which still is significantly lower than in the U.S. population.

Table 4.5: Body Mass Index of Swiss Males, Aged 18 – 50

Dependent Variable: BMI Variable	Model 1	(Standard Error)	Model 2	(Standard Error)	Model 3	(Standard Error)	Model 4	(Standard Error)	Model 5	(Standard Error)
Age Group										
18 - 22 years	-2.05***	(0.24)	-2.21***	(0.30)	-2.02***	(0.31)	-2.04***	(0.31)	-2.13***	(0.31)
23 - 27 years	-0.74**	(0.29)	-0.83***	(0.29)	-0.68**	(0.29)	-0.69**	(0.29)	-0.72**	(0.29)
28 - 32 years	Ref.		Ref.		Ref.		Ref.		Ref.	
33 - 37 years	0.31	(0.26)	0.27	(0.26)	0.17	(0.26)	0.14	(0.26)	0.11	(0.26)
38 - 42 years	0.78***	(0.27)	0.63**	(0.27)	0.45	(0.29)	0.44	(0.29)	0.40	(0.29)
43 - 50 years	0.87***	(0.25)	0.71***	(0.25)	0.46*	(0.28)	0.46*	(0.28)	0.39	(0.28)
Education										
None			-1.29**	(0.60)	-1.22**	(0.58)	-1.23**	(0.61)	-1.17**	(0.60)
Compulsory School			-0.38	(0.43)	-0.34	(0.43)	-0.35	(0.43)	-0.28	(0.43)
Apprenticeship			-0.28	(0.24)	-0.28	(0.24)	-0.27	(0.24)	-0.25	(0.23)
Higher Job Training			Ref.		Ref.		Ref.		Ref.	
High School Diploma			-1.00***	(0.32)	-0.93***	(0.32)	-0.85***	(0.32)	-0.78**	(0.32)
College Degree			-1.36***	(0.24)	-1.32***	(0.23)	-1.25***	(0.23)	-1.22***	(0.23)
No Answer			-0.84	(0.96)	-0.88	(0.97)	-0.75	(0.97)	-0.76	(1.03)
Marital Status										
unmarried					-0.51**	(0.20)	-0.48**	(0.20)	-0.48**	(0.20)
married					Ref.		Ref.		Ref.	
divorced					-0.05	(0.38)	0.01	(0.38)	0.02	(0.38)
widowed					3.57***	(1.03)	3.38***	(1.00)	3.22***	(1.02)
Type of Community of Residence										
Urban							Ref.		Ref.	
Rural							0.34*	(0.20)	0.27	(0.20)
Wealthy Community							-0.32	(0.44)	-0.25	(0.44)
Tourist Community							1.02**	(0.49)	1.14**	(0.50)
Industrial Community							0.59**	(0.28)	0.56**	(0.28)
Region of Residence										
Lake Geneva									-0.45*	(0.23)
Espace Mittelland									0.26	(0.23)
Zurich Region									Ref.	
Northwestern									0.42*	(0.25)
Eastern									0.01	(0.26)
Central									-0.01	(0.26)
Ticino									-0.17	(0.42)
Intercept	24.49***	(0.20)	25.19***	(0.28)	25.47***	(0.29)	25.30***	(0.30)	25.29***	(0.33)
Adjusted R^2	0.08		0.10		0.10		0.11		0.11	
F	55.714		30.748		27.500		22.324		17.351	

Source: SHP 2004. Note: results are given in kg/ m². * Significant at the 10% level, ** Significant at the 5% level, *** Significant at the 1% level.

Table 4.6: Body Mass Index of Swiss Females, Aged 18 – 50

Dependent Variable: BMI Variable	Model 1	(Standard Error)	Model 2	(Standard Error)	Model 3	(Standard Error)	Model 4	(Standard Error)	Model 5	(Standard Error)
Age Group										
18 - 22 years	-0.99***	(0.26)	-1.18***	(0.28)	-1.13***	(0.30)	-1.13***	(0.30)	-1.10***	(0.29)
23 - 27 years	-0.29	(0.30)	-0.25	(0.30)	-0.22	(0.30)	-0.26	(0.30)	-0.18	(0.30)
28 - 32 years	Ref.		Ref.		Ref.		Ref.		Ref.	
33 - 37 years	0.58**	(0.29)	0.49*	(0.29)	0.48	(0.30)	0.46	(0.30)	0.46	(0.30)
38 - 42 years	0.21	(0.25)	0.11	(0.25)	0.09	(0.27)	0.08	(0.27)	0.08	(0.27)
43 - 50 years	0.83***	(0.26)	0.68***	(0.26)	0.66**	(0.28)	0.65**	(0.28)	0.65**	(0.28)
Education										
None			0.13	(0.68)	0.13	(0.68)	0.07	(0.68)	0.04	(0.67)
Compulsory School			0.75**	(0.31)	0.74**	(0.31)	0.68**	(0.31)	0.66**	(0.31)
Apprenticeship			0.57**	(0.26)	0.56**	(0.26)	0.49*	(0.26)	0.49*	(0.26)
Higher Job Training			Ref.		Ref.		Ref.		Ref.	
High School Diploma			-0.16	(0.30)	-0.17	(0.30)	-0.19	(0.30)	-0.21	(0.31)
College Degree			-0.67**	(0.27)	-0.67**	(0.27)	-0.65**	(0.27)	-0.64**	(0.27)
No Answer			0.51	(1.29)	0.49	(1.29)	0.42	(1.30)	0.25	(1.30)
Marital Status										
unmarried					-0.10	(0.23)	-0.06	(0.23)	-0.10	(0.23)
married					Ref.		Ref.		Ref.	
divorced					-0.11	(0.26)	-0.06	(0.26)	-0.06	(0.26)
widowed					-0.18	(0.65)	-0.13	(0.63)	-0.22	(0.62)
Type of Community of Residence										
Urban							Ref.		Ref.	
Rural							0.46**	(0.20)	0.39*	(0.21)
Wealthy Community							-0.60*	(0.32)	-0.52	(0.33)
Tourist Community							0.91*	(0.52)	1.15**	(0.52)
Industrial Community							0.44*	(0.26)	0.49*	(0.27)
Region of Residence										
Lake Geneva									-0.33	(0.25)
Espace Mittelland									0.30	(0.24)
Zurich Region									Ref.	
Northwestern									0.40	(0.27)
Eastern									-0.43	(0.28)
Central									-0.28	(0.27)
Ticino									-0.81**	(0.39)
Intercept	22.38***	(0.21)	22.22***	(0.29)	22.28***	(0.33)	22.20***	(0.33)	22.24***	(0.38)
Adjusted R^2	0.02		0.04		0.04		0.04		0.05	
F	16.771		12.873		10.387		8.979		8.144	

Source: SHP 2004. Note: results are given in kg/ m². * Significant at the 10% level, ** Significant at the 5% level, *** Significant at the 1% level.

of the body is completed, so that the metabolic system has excess energy available which is stored by the body in form of fat, thus leading to higher BMI values. Furthermore, there are also hormonal changes and a more sedentary lifestyle when adulthood is reached, both requiring a lower level of caloric intake.

The results for the educational status show that among both males and females lower educational status implies higher BMI. All kinds of education that focuses on the practical aspects of work, such as vocational training and apprenticeships, correlate with higher BMI among females, while the differences among males is not statistically significant. Academic levels, such as college degrees (and, for males, also high school graduates), coincide with lower BMI values. The magnitude of the coefficients is not very large, with most of the coefficients smaller than 1 kg/ m^2 (roughly 3.3 kg for an average man with a height of 180 cm). Since the educational level serves as an indicator of the socioeconomic status of the subjects, these results show that members of lower social segments have higher BMI. Low educational status can be considered as the outcome of an investment decision with respect to human capital. The decision to invest smaller amounts into human capital would be affected by an individual's high rate of time preference.[62] Similarly, if the rate of time preference is high, this would also affect the individual's attitude towards its health, and make it less likely that the individual decides to forego current consumption for future health benefits (Borghans and Golsteyn 2006, Komlos et al. 2004). Thus, lower educational status and a tendency to be overweight can both be affected by a higher rate of time preference. Unfortunately, time preference is difficult to measure and therefore often approximated by information on the

62 „Time preference is the rate at which people are willing to trade current benefit (utility) for future benefit and is often used in economics to explain savings and investment behavior. Having low time preference means a person is patient and has good self-control, i.e., s/he values the future." (Smith et al. 2005)

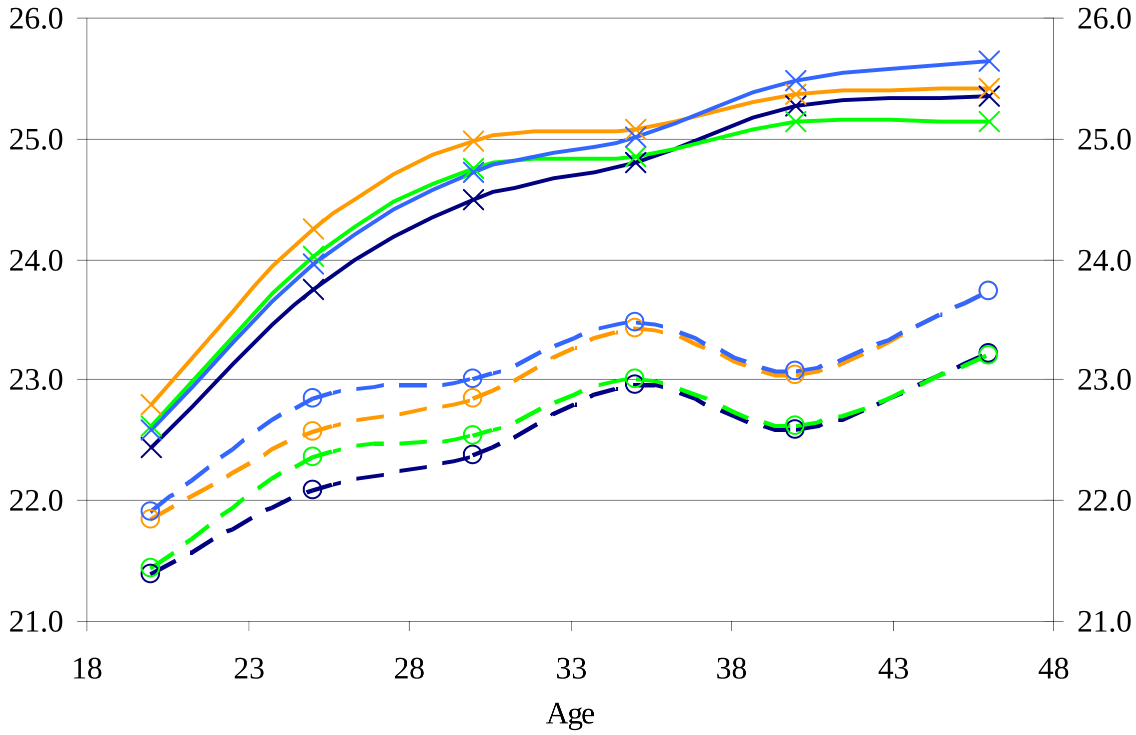
savings and investment behavior of individuals (Borghans and Golsteyn 2006, Smith et al. 2005). The Swiss Household Panel contains only a small amount of information in this regard, and the respective information is aggregated at the household level, making it difficult to proxy individual discount rates. But the basic pattern of a relation between low educational status and high time preference has also been found in study by Fuchs (1982).

There is no significant influence of marital status on the BMI of females. Unmarried males, however, are slightly lighter than married ones, and widowers have a much higher BMI. Yet, the number of widowers (N=9) is too small to draw any meaningful conclusions from these results. The coefficient for unmarried men is negative for both stature and BMI, while for most of the other variables, the signs show up in opposite directions. This may indicated that women consider taller and bigger men a better choice for marriage, as these attributes may indicate a better ability to supply and sustain a household. Likewise, taller stature is also typically associated with a higher level of income (Heineck 2004).

Urban citizens are significantly lighter than those from rural and industrial regions. The results are similar for both males and females. Tourist communities – a classification which in Switzerland mostly refers to mountainous resorts and therefore rural communities – show very similar effects in direction and in magnitude. Industrial communities, likely to be inhabited by subjects with a lower socio-economic status exhibit the same properties.

The spatial control variable for the different regions of Switzerland show no clearly significant pattern: While there is some indication that males from the Northwestern Switzerland are slightly heavier, and male residents in the Region of Lake Geneva are marginally less heavy, the remaining coefficients for males are insignificant, while women from Ticino show significantly lower body weights. The remaining insignificant coefficients show the same trend as the male ones.

Figure 4.5: Body Mass Index (kg/ m²) of Swiss Males and Females 2004



Source: Table 4.5, Table 4.6, Table 4.12 and Table 4.13

Discussion

While in a historical context stagnation or a decline in height was in general related to disadvantageous developments in the nutritional status of the respective population – caused by unfavorable harvests, urbanization, or sheer scarcity of food due to strong population growth (Komlos 1989) – stagnation in times of economic growth is more puzzling. Research on the recent Anthropometric History of the United States has suggested inequality among the population, insufficient health care and deficient diets as the main contributors for not achieving the population's genetic potential (Komlos and Lauderdale 2007, Komlos and Baur 2003). Populations living in what is currently referred to as welfare states, such as Norway, Denmark and Sweden, on the other hand, have overtaken the U.S. population in height in the course of the second half of the 20th century. Sunder (2003) uses the assumption of diminishing marginal returns to income on the Biological Standard of Living (as indicated by height) to argue that redistribution of income leads to a higher average biological welfare. The redistribution in the context is not limited to direct income transfers, but works through state-provided health services, unemployment benefits and other channels as well.

Caloric Intake

Data on the nutritional situation in Switzerland (Stransky and Blumenthal 1986, Schweizerischer Bauernverband 2004) indicate that the per capita intake of calories is sufficient. Stransky and Blumenthal report about 13.000 kJ per capita excluding calories from

Table 4.7: Caloric Intake in Switzerland.

	kJ	kcal
1973	13,063	3,122
1980	12,888	3,080
2001	12,984	3,103
2004	13,391	3,200
RDI[63] (male, 25-50)	12,134	2,900
RDI (female, 25-50)	9,623	2,300

Source: Stransky and Blumenthal 1986, Schweizerischer Bauernverband 2004

alcoholic beverages for the 1970s and the 1980, and the most recent nutritional balance sheet published by the Swiss Farmers Association shows even slightly higher values for the early 2000s. This is well above the recommended levels by the German Nutrition Society. Other institutions recommend similar levels: the British Nutrition Foundation (2004) suggests 10.600 (8.000) kJ for males (females) aged between 19 and 50 based on the current lifestyle in the UK, which is described as “fairly sedentary”. A higher level of physical activity would also require a higher amount of energy intake. The recommendations given in the Dietary Guidelines for Americans, published jointly by the U.S. Department of Agriculture and U.S.

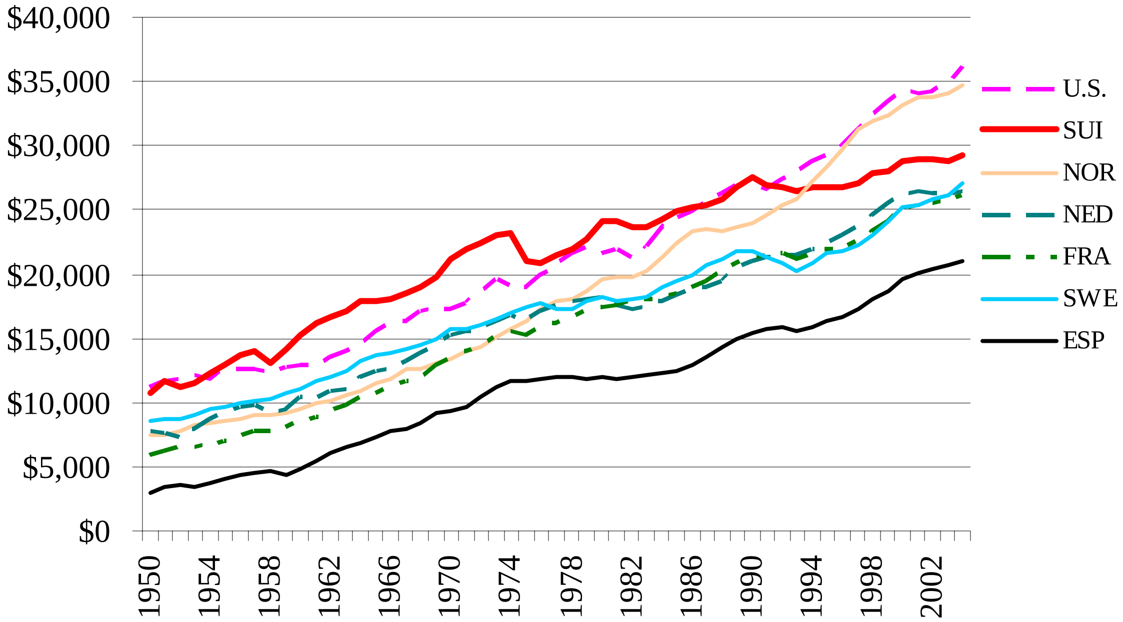
[63] RDI = Recommended Daily Intake. Data is given for adult individuals of average height and weight, based on light workload only

Department of Health and Human Services (2005), are in line with the previously mentioned ones.

Economic Growth, Income Equality, Government Spending

Similarly, the economic situation is Switzerland is favorable: Real (i.e. in terms of purchasing power parity) per capita GDP is high in international comparison (Figure 4.6), even though the growth has been lagging behind the most successful countries since the 1990s.

Figure 4.6: Real Per Capita GDP for Selected Countries, 1950-2004



Source: Heston et al. 2006

When comparing Figure 4.3 to Figure 4.6, it is striking to see that the per capita GDP in Switzerland was increasing rapidly from the 1950s to the 1970s when the physical stature was increasing as well. From the late 1970s on, growth in per capita income as well as in height slowed down together.

So given the economic and nutritional foundations, what are the reasons that Swiss population – in contrast to the U.S. – managed to keep up fairly with the tallest populations in the world?

Contrary to the Scandinavian welfare states, Switzerland has traditionally a less extensive social safety net. The central governments spending as a share of the GDP is astonishingly low with less than 10%; even if all the levels of government are taken into consideration the spending is more in the vicinity of the U.S. Figure and rather far away from the value typical for Scandinavian welfare states (IDW 2006). The pre-tax and transfer income Gini coefficient of Switzerland is similar to the values of the Scandinavian societies; yet the extent of the transfers is much smaller: While Scandinavian governments in the mean reduce the income Gini coefficient from 0.315 to about 0.208 with taxes and transfers, Switzerland's transfers only reduce the value from 0.335 to 0.305 (Bradley et al. 2003). For comparison, the respective U.S. values are 0.378 (pre-transfer) and 0.328 (post-transfer).[64] Hence with respect to equality measures, Switzerland is certainly more in line with the U.S. than with Scandinavian or other European welfare states. Subsequently, the level of equality seems not to be the driving force of the different developments in average stature during the second half of the 20th century in the U.S. and Switzerland. Apparently, the pattern of income inequality does not provide a sufficient explanation for the different developments in height in Switzerland, the U.S. and the Scandinavian states.

Health in Switzerland

It is important to note that the health care system and its output do not produce health itself. Rather, the output of the health care system is health care services, which is best viewed as an intermediate product in the production of health. Hence, any data on the health care system –

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[64] With some differences in magnitude, similar results are provided by the World Income Inequality Distribution Database, available from http://www.wider.unu.edu/wiid/wiid.htm and the World Development Report published by the World Bank (2001)

especially in international comparison – should be amended by data on the health status and distribution.

In terms of spending on the health system (measured as percentage of GDP), Switzerland sustains one the most expensive health care systems in the world, second only the U.S. and Germany (Table 4.8).[65] Yet if the attainment and performance[66] of the health care system are considered, the discrepancy between Switzerland and the U.S. on the one side and the

Table 4.8: Statistics on Health Care Systems of Selected Countries

	Health Care Spending (in % of GDP), 1997	Rank by overall attainment	Rank by overall performance
France	9.8	6	1
Germany	10.5	14	25
Netherlands	8.8	8	17
Norway	6.5	3	11
Spain	8	19	7
Sweden	9.2	4	23
Switzerland	*10.1*	*2*	*20*
United States	13.7	15	37

Source: WHO 2000

similarity between Switzerland and the Northern Europe on the other is more intriguing: with respect to the overall performance and especially attainment, Switzerland is more in line with the remaining European Countries, while the U.S. lag behind by quite a bit.

As the data of the SHP covers subjects born between 1954 and 1985, we focus on the Swiss Health Care System prior to the legal reform of 1994, which came into force in 1996.

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65 Other sources, such as the World Development Report published by the World Bank (2001) report different values that place Switzerland second behind Sweden among those coutries listed above.

66 The attainment of the health care system is measured in a composite index based on level of and distribution of health, level and distribution of responsiveness and fairness of financial contributions. Performance, on the other hand, serves as indicator how efficiently health care expenditures translate into health measured by disability-adjusted life expectancy. See WHO (2000) for details.

The Swiss health system can be characterized as a liberal system that accounts for the federal structure of Switzerland. Most aspects of the health care system, such as financing, organization and delivery, are responsibility of the cantons (Minder et al. 2000). There was no federal compulsory health insurance, but four cantons did make insurance compulsory for the overall population, and some other cantons did require special groups, such as children, the elderly and the poor, to be insured. Still, the rate of voluntary insurance was high – 98% of the population was insured during this period. Insurance funds were required to provide a package of compulsory basic benefits,[67] but did have the discretion to set premiums for different ages and sexes. Financial aid is given to poorer families and individuals. In fact, the perceived amount of inequality within the Swiss health care system was so small that it took until 1994 that the populace voted in favor of a major reform (Holly and Benkassmi 2003). In short, the liberal structure of the Swiss health care system did not result in large amounts of stratification within the Swiss population.

Health as the final outcome of the health care system and the services it provides by this system is quite difficult to measure. Common objective indicators are life expectancy and infant mortality. Table 4.9 shows that the infant mortality (deaths during the first year of life divided by 1.000 life births) in Switzerland has decreased significantly since the middle of the 20th Century. The decline is in line with the experiences of most other Western European countries. Only the U.S. show a notably higher infant mortality rate.

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67 „Basic“ package is a misleading term, as it does not refer to a low standard of service, but describes the minimum package that has to offered by each registered health insurance company. In comparison to other countries, this basic statutory package likens “to a luxury package in the U.S. or Germany” (Civitas 2002).

Table 4.9: Infant Mortality Rates for Selected Countries

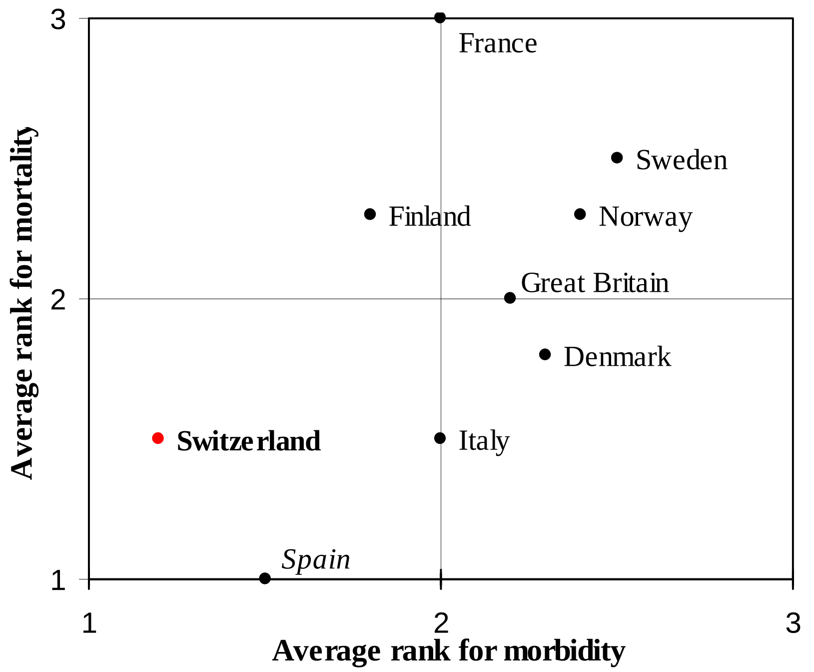
	Switzerland	Norway	France	Spain	Sweden	Netherlands	U.S.
MALE							
1951	33.8	28.9	55.6	67.9	24.4	28.1	32.0
1961	23.9	20.3	24.3	40.4	17.7	17.8	28.4
1971	16.7	15.0	16.0	21.3	12.5	13.9	21.4
1981	8.7	8.5	11.2	14.1	7.4	9.4	13.1
1991	7.1	6.9	8.3	7.9	6.6	7.7	10.0
2001	5.6	4.4	5.0	3.5	4.0	5.9	7.5
FEMALE							
	Switzerland	Norway	France	Spain	Sweden	Netherlands	U.S.
1951	26.2	22.2	42.9	56.4	18.6	20.6	24.7
1961	18.0	15.3	18.9	33.6	13.7	12.3	22.0
1971	12.0	10.4	12.3	16.4	9.5	9.7	16.7
1981	6.4	6.5	8.2	10.8	6.5	6.9	10.7
1991	5.3	5.8	6.1	6.4	5.6	5.0	7.8
2001	4.4	3.7	3.9	3.7	3.3	4.6	6.1

Source: WHO Mortality database

Other measures of health are more subjective measures, such as self-reported morbidity. These figures are mostly of interest in comparison, either between socio-economic groups or between countries. Such data also allows comparing the amount of inequality within a society and then comparing the amount of inequality between countries. While there are several methods of measuring inequalities in health, most of them do not take socio-economic differences within the population into account. Plain measures such as the range (i.e. the difference between the top socio-economic group and the bottom group) or the Gini coefficient of health do not reflect the socio-economic dimension to inequality in health (Wagstaff et al. 1991). The range fails to reflect experiences of the entire population and is not sensitive to changes across socio-economic groups, while the Gini coefficient of health does not uncover systematic relations between socio-economic status and health (if a sick person with a high socio-economic status became less ill, and a person with a low socio-economic status became sick, the mean would remain unchanged but the level of inequality, as measured by the Gini coefficient of health would be reduced).

Mackenbach et al. (1997) calculate odds-ratio between rather broad upper and lower socio-economic group, showing that Switzerland has a rather low level of inequality in health, and that the probability of low self-perceived general health among the lower group (compared to members of the higher group) is much higher in Norway, Sweden, the Netherlands and other western European countries. They also calculate average rankings of the relative inequality based on both morbidity and mortality. Figure 4.7 shows a matrix with the respective results:

Figure 4.7: Average Ranking of Health Inequality in International Comparison



Source: Mackenbach et al. 1997
Note: 1 = top rank, 2 = middle rank , 3 = bottom rank

The high ranking of Switzerland is striking; the even lower rank with regard to mortality of Spain is based on a single observation and should therefore be considered preliminary. All of these findings are further corroborated by the results obtained by Cavelaars et al. (1998a and 1998b). More recently Leu and Schellberg (2006) have shown that the income-related health inequality in Switzerland is relatively low using a health concentration index;[68] a comparison with estimates pertaining to other European countries (van Doerslaer and Koolman 2004) shows that only the Netherlands enjoyed an even lower level of income-related inequality in health.

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[68] A detailed description of the concentration index and its advantages over other measures of inequality in health can be found in Kakwani et al. (1997).

In spite of (or perhaps even because of) the liberal structure of the Swiss Health System, the data shows that the inequality in health in Switzerland is at a very low level. The Scandinavian welfare states and the Netherlands, with more state-intervention in the health care sector, fare considerable worse than Switzerland and show much higher levels of inequality in health.

Returning to the potential explanations for the high biological standard of living as measured by height in Switzerland, the key driver seems to be the quality, performance and attainment of the health care system and the low level of inequality in health in Switzerland. We suggest three specific properties of the Swiss health system as explanations for the low level of inequality in health among the Swiss:

1.) The strong element of direct democracy typical for Switzerland enables the Swiss citizens to influence the structure of the system to a larger degree than it is possible in other countries. The federal structure allows for decisions close to the people, and the influence through referenda in turn allows them to shape the system according to their preferences.

2.) Competition between providers of health care as well as between providers of health insurance allows furthermore for ‘voting with the feet’: Inefficient providers of health care and of health insurance are eliminated by the forces of the market. Especially in recent times, the Swiss have become more willing to switch insurance companies. Between 1945 and 2002, the number of registered insurance funds fell from 1.151 to 93, showing a considerable amount of consolidation in the industry (Civitas 2002).

3.) An unusual mix between public and private contributions to the system: The different levels of government contribute roughly the same amount of the total health care expenditures as subsidies to hospitals and nursing homes as the statutory health insurances pay. Furthermore, the individual insurance contracts allow for different levels of deductibles, introducing a considerable amount of cost sharing into the system. The co-payments support cost-consciousness among the patients and avoid unnecessary and excessive use of the health care system.

Conclusion

The secular increase in the mean stature of the Swiss population between 1955 and 1980 indicates an improvement of the Biological Standard of Living in Switzerland. Based on solid economic growth and a high level of per capita income, the Swiss population has reached similar levels in height as the populations of Northern and Western Europe, and therefore belongs to the group of the tallest people in the world. This is even more so among females than males. Common explanatory factors typical for extensive welfare state, such as income redistribution, public health insurance and a wide-ranging social net, as it is prevalent in the Scandinavian countries and the Netherlands, cannot be found in the rather liberal design of the Swiss Confederation. An extraordinary low level of health inequality – among the lowest in Western Europe, and much lower than in the typical welfare states – seems to influence the average biological standard of living in a favorable way. The interactions between the equality of income, equality of health and the Biological Standard of Living certainly deserve further scrutiny and research.

Acknowledgement

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Appendix I

Table 4.10: Adjusted Height of Swiss Males, Aged 18 - 50

Dependent Variable: Stature Variable	Model 1	(Standard Error)	Model 2	(Standard Error)	Model 3	(Standard Error)	Model 4	(Standard Error)	Model 5	(Standard Error)
Birth Cohort										
1981 - 1986	-0.60	(0.47)	-0.45	(0.53)	-0.21	(0.55)	-0.16	(0.55)	-0.18	(0.54)
1976 - 1980	0.03	(0.55)	0.12	(0.56)	0.31	(0.57)	0.34	(0.57)	0.33	(0.57)
1971 - 1975	Ref.		Ref.		Ref.		Ref.		Ref.	
1966 - 1970	-1.28***	(0.48)	-1.26***	(0.47)	-1.36***	(0.48)	-1.32***	(0.48)	-1.28***	(0.48)
1961 - 1965	-2.10***	(0.44)	-1.95***	(0.44)	-2.14***	(0.45)	-2.11***	(0.44)	-2.06***	(0.44)
1954 - 1960	-2.31***	(0.43)	-2.15***	(0.43)	-2.33***	(0.45)	-2.30***	(0.45)	-2.32***	(0.45)
Education										
None			0.15	(1.22)	0.26	(1.22)	0.25	(1.24)	0.22	(1.24)
Compulsory School			0.54	(0.62)	0.65	(0.62)	0.65	(0.62)	0.65	(0.62)
Apprenticeship			0.10	(0.38)	0.15	(0.38)	0.12	(0.38)	0.12	(0.38)
Higher Job Training			Ref.		Ref.		Ref.		Ref.	
High School Diploma			1.11**	(0.55)	1.22**	(0.55)	1.08*	(0.55)	1.02*	(0.55)
College Degree			1.42***	(0.41)	1.46***	(0.41)	1.33***	(0.41)	1.33***	(0.41)
No Answer			-1.33	(2.55)	-1.41	(2.48)	-1.58	(2.48)	-1.66	(2.52)
Marital Status										
unmarried					-0.72**	(0.34)	-0.77**	(0.34)	-0.78**	(0.34)
married					Ref.		Ref.		Ref.	
divorced					-0.71	(0.52)	-0.80	(0.53)	-0.83	(0.53)
widowed					-1.72	(1.90)	-1.40	(1.92)	-1.35	(1.93)
Type of Community of Residence										
Urban							Ref.		Ref.	
Rural							-0.89**	(0.35)	-0.85**	(0.36)
Wealthy Community							0.41	(0.68)	0.23	(0.68)
Tourist Community							-1.39*	(0.74)	-1.17	(0.75)
Industrial Community							-0.38	(0.44)	-0.19	(0.44)
Region of Residence										
Lake Geneva									0.29	(0.45)
Espace Mittelland									-0.11	(0.40)
Zurich Region									Ref.	
Northwestern									0.77	(0.47)
Eastern									-0.84*	(0.46)
Central									-0.24	(0.47)
Ticino									-0.83	(0.69)
Intercept	178.46***	(0.35)	177.81***	(0.47)	178.20***	(0.50)	178.46***	(0.51)	178.49***	(0.58)
Adjusted R^2	0.02		0.03		0.03		0.03		0.04	
F	10.746		6.996		6.039		5.278		4.357	

Source: SHP 2004. Note: results are given in centimeters. * Significant at the 10% level, ** Significant at the 5% level, *** Significant at the 1% level.

Appendix I

Table 4.11: Adjusted Height of Swiss Females, Aged 18 - 50

Dependent Variable: Stature Variable	Model 1	(Standard Error)	Model 2	(Standard Error)	Model 3	(Standard Error)	Model 4	(Standard Error)	Model 5	(Standard Error)
Birth Cohort										
1981 - 1986	-0.86**	(0.41)	-0.41	(0.43)	-0.65	(0.46)	-0.65	(0.46)	-0.64	(0.46)
1976 - 1980	0.09	(0.43)	0.10	(0.43)	-0.04	(0.43)	-0.04	(0.43)	-0.05	(0.43)
1971 - 1975	Ref.		Ref.		Ref.		Ref.		Ref.	
1966 - 1970	-0.55	(0.38)	-0.44	(0.38)	-0.36	(0.38)	-0.35	(0.38)	-0.36	(0.38)
1961 - 1965	-1.31***	(0.36)	-1.17***	(0.36)	-1.05***	(0.37)	-1.05***	(0.38)	-1.07***	(0.37)
1954 - 1960	-2.01***	(0.35)	-1.81***	(0.35)	-1.67***	(0.37)	-1.66***	(0.37)	-1.67***	(0.37)
Education										
None			-2.31	(1.41)	-2.31	(1.41)	-2.28	(1.42)	-2.20	(1.44)
Compulsory School			-1.15***	(0.44)	-1.08**	(0.45)	-1.07**	(0.45)	-1.04**	(0.45)
Apprenticeship			-0.45	(0.37)	-0.39	(0.37)	-0.36	(0.37)	-0.36	(0.37)
Higher Job Training			Ref.		Ref.		Ref.		Ref.	
High School Diploma			0.03	(0.44)	0.07	(0.44)	0.08	(0.45)	0.10	(0.45)
College Degree			0.79*	(0.42)	0.78*	(0.42)	0.77*	(0.42)	0.79*	(0.42)
No Answer			-0.39	(1.37)	-0.32	(1.38)	-0.28	(1.38)	-0.17	(1.41)
Marital Status										
unmarried					0.42	(0.28)	0.40	(0.29)	0.36	(0.29)
married					Ref.		Ref.		Ref.	
divorced					-0.23	(0.38)	-0.25	(0.38)	-0.28	(0.38)
widowed					0.68	(1.58)	0.66	(1.57)	0.80	(1.65)
Type of Community of Residence										
Urban							Ref.		Ref.	
Rural							-0.19	(0.28)	-0.16	(0.29)
Wealthy Community							0.12	(0.57)	0.07	(0.57)
Tourist Community							-0.08	(0.69)	0.05	(0.69)
Industrial Community							-0.09	(0.35)	-0.05	(0.35)
Region of Residence										
Lake Geneva									-0.39	(0.37)
Espace Mittelland									-0.56*	(0.32)
Zurich Region									Ref.	
Northwestern									-0.19	(0.37)
Eastern									-0.31	(0.39)
Central									0.12	(0.38)
Ticino									-1.43**	(0.59)
Intercept	166.59***	(0.29)	166.70***	(0.42)	166.48***	(0.45)	166.51***	(0.46)	166.83***	(0.50)
Adjusted R^2	0.02		0.03		0.03		0.03		0.03	
F	10.662		7.615		6.380		5.052		4.190	

Source: SHP 2004. Note: results are given in centimeters. * Significant at the 10% level, ** Significant at the 5% level, *** Significant at the 1% level.

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Table 4.12: Adjusted BMI of Swiss Males, Aged 18 - 50

Dependent Variable: BMI Variable	Model 1	(Standard Error)	Model 2	(Standard Error)	Model 3	(Standard Error)	Model 4	(Standard Error)	Model 5	(Standard Error)
Age Group										
18 - 22 years	-2.05***	(0.24)	-2.21***	(0.30)	-2.02***	(0.31)	-2.04***	(0.31)	-2.13***	(0.31)
23 - 27 years	-0.74**	(0.29)	-0.83***	(0.29)	-0.68**	(0.29)	-0.69**	(0.29)	-0.72**	(0.29)
28 - 32 years	Ref.		Ref.		Ref.		Ref.		Ref.	
33 - 37 years	0.31	(0.26)	0.27	(0.26)	0.17	(0.26)	0.14	(0.26)	0.11	(0.26)
38 - 42 years	0.78***	(0.27)	0.63**	(0.27)	0.45	(0.29)	0.44	(0.29)	0.40	(0.29)
43 - 50 years	0.87***	(0.25)	0.71***	(0.25)	0.46*	(0.28)	0.46*	(0.28)	0.39	(0.28)
Education										
None			-1.29**	(0.60)	-1.22**	(0.58)	-1.23**	(0.61)	-1.17**	(0.60)
Compulsory School			-0.38	(0.43)	-0.34	(0.43)	-0.35	(0.43)	-0.28	(0.43)
Apprenticeship			-0.28	(0.24)	-0.28	(0.24)	-0.27	(0.24)	-0.25	(0.23)
Higher Job Training			Ref.		Ref.		Ref.		Ref.	
High School Diploma			-1.00***	(0.32)	-0.93***	(0.32)	-0.85***	(0.32)	-0.78**	(0.32)
College Degree			-1.36***	(0.24)	-1.32***	(0.23)	-1.25***	(0.23)	-1.22***	(0.23)
No Answer			-0.84	(0.96)	-0.88	(0.97)	-0.75	(0.97)	-0.76	(1.03)
Marital Status										
unmarried					-0.51**	(0.20)	-0.48**	(0.20)	-0.48**	(0.20)
married					Ref.		Ref.		Ref.	
divorced					-0.05	(0.38)	0.01	(0.38)	0.02	(0.38)
widowed					3.57***	(1.03)	3.38***	(1.00)	3.22***	(1.02)
Type of Community of Residence										
Urban							Ref.		Ref.	
Rural							0.34*	(0.20)	0.27	(0.20)
Wealthy Community							-0.32	(0.44)	-0.25	(0.44)
Tourist Community							1.02**	(0.49)	1.14**	(0.50)
Industrial Community							0.59**	(0.28)	0.56**	(0.28)
Region of Residence										
Lake Geneva									-0.45*	(0.23)
Espace Mittelland									0.26	(0.23)
Zurich Region									Ref.	
Northwestern									0.42*	(0.25)
Eastern									0.01	(0.26)
Central									-0.01	(0.26)
Ticino									-0.17	(0.42)
Intercept	24.49***	(0.20)	25.19***	(0.28)	25.47***	(0.29)	25.30***	(0.30)	25.29***	(0.33)
Adjusted R^2	0.08		0.10		0.10		0.11		0.11	
F	55.714		30.748		27.500		22.324		17.351	

Source: SHP 2004. Note: results are given in kg/ m². * Significant at the 10% level, ** Significant at the 5% level, *** Significant at the 1% level.

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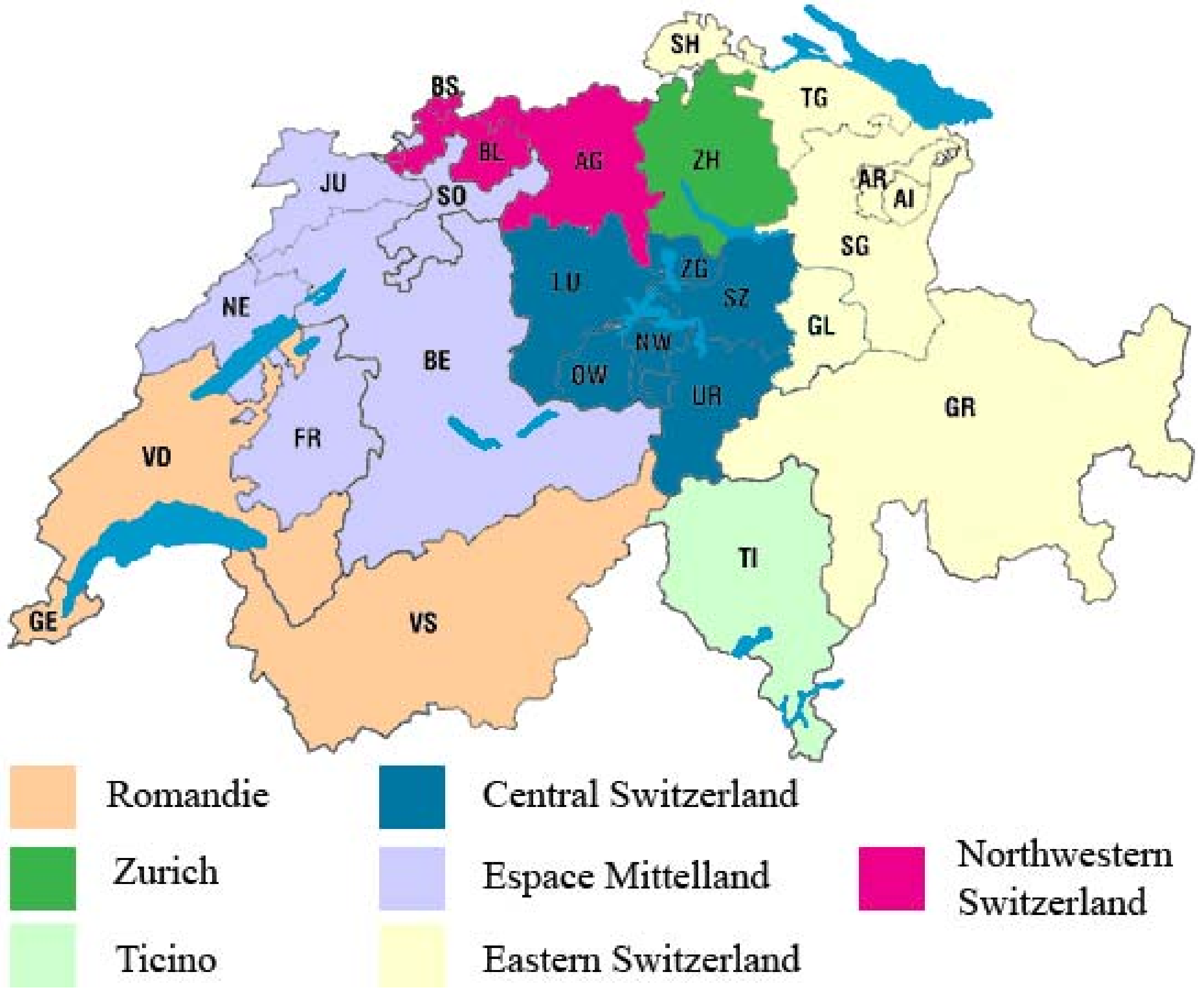
Table 4.13: Adjusted BMI of Swiss Females, Aged 18 - 50

Dependent Variable: BMI Variable	Model 1	(Standard Error)	Model 2	(Standard Error)	Model 3	(Standard Error)	Model 4	(Standard Error)	Model 5	(Standard Error)
Age Group										
18 - 22 years	-0.99***	(0.26)	-1.18***	(0.28)	-1.13***	(0.30)	-1.13***	(0.30)	-1.10***	(0.29)
23 - 27 years	-0.29	(0.30)	-0.25	(0.30)	-0.22	(0.30)	-0.26	(0.30)	-0.18	(0.30)
28 - 32 years	Ref.		Ref.		Ref.		Ref.		Ref.	
33 - 37 years	0.58**	(0.29)	0.49*	(0.29)	0.48	(0.30)	0.46	(0.30)	0.46	(0.30)
38 - 42 years	0.21	(0.25)	0.11	(0.25)	0.09	(0.27)	0.08	(0.27)	0.08	(0.27)
43 - 50 years	0.83***	(0.26)	0.68***	(0.26)	0.66**	(0.28)	0.65**	(0.28)	0.65**	(0.28)
Education										
None			0.13	(0.68)	0.13	(0.68)	0.07	(0.68)	0.04	(0.67)
Compulsory School			0.75**	(0.31)	0.74**	(0.31)	0.68**	(0.31)	0.66**	(0.31)
Apprenticeship			0.57**	(0.26)	0.56**	(0.26)	0.49*	(0.26)	0.49*	(0.26)
Higher Job Training			Ref.		Ref.		Ref.		Ref.	
High School Diploma			-0.16	(0.30)	-0.17	(0.30)	-0.19	(0.30)	-0.21	(0.31)
College Degree			-0.67**	(0.27)	-0.67**	(0.27)	-0.65**	(0.27)	-0.64**	(0.27)
No Answer			0.51	(1.29)	0.49	(1.29)	0.42	(1.30)	0.25	(1.30)
Marital Status										
unmarried					-0.10	(0.23)	-0.06	(0.23)	-0.10	(0.23)
married					Ref.		Ref.		Ref.	
divorced					-0.11	(0.26)	-0.06	(0.26)	-0.06	(0.26)
widowed					-0.18	(0.65)	-0.13	(0.63)	-0.22	(0.62)
Type of Community of Residence										
Urban							Ref.		Ref.	
Rural							0.46**	(0.20)	0.39*	(0.21)
Wealthy Community							-0.60*	(0.32)	-0.52	(0.33)
Tourist Community							0.91*	(0.52)	1.15**	(0.52)
Industrial Community							0.44*	(0.26)	0.49*	(0.27)
Region of Residence										
Lake Geneva									-0.33	(0.25)
Espace Mittelland									0.30	(0.24)
Zurich Region									Ref.	
Northwestern									0.40	(0.27)
Eastern									-0.43	(0.28)
Central									-0.28	(0.27)
Ticino									-0.81**	(0.39)
Intercept	22.38***	(0.21)	22.22***	(0.29)	22.28***	(0.33)	22.20***	(0.33)	22.24***	(0.38)
Adjusted R^2	0.02		0.04		0.04		0.04		0.05	
F	16.771		12.873		10.387		8.979		8.144	

Source: SHP 2004. Note: results are given in kg/ m². * Significant at the 10% level, ** Significant at the 5% level, *** Significant at the 1% level.

Appendix II

Figure 4.8: Regional Division of Switzerland



Source: Federal Office of Statistics

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