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THE PHYSICAL STATURE AND BMI VALUES OF US ARMY PERSONNEL IN 1988

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Summary. The US Army's 1988 Anthropometric Survey (ANSUR) data set is analysed in order to estimate the secular trend of their physical stature and body mass index while controlling for ethnic composition as well as place of birth of their parents. Separate analysis for blacks and whites stratified by gender is presented. The stature of the American population remained constant during most of the period considered, and no substantial ethnic or spatial effects were found. These results add further support to trends based on the National Health and Nutrition Examination Surveys and imply that the stagnation in height found in those data sets is most probably not biased by the omitted variables pertaining to own ethnicity or second-generation effects of parents' ethnicity or foreign birth.

Introduction

The mean physical stature attained by a population is a function of its cumulative (net) nutritional experience during infancy, childhood and adolescence. The improvements in general living standards over the last one and a half centuries have led to a secular increase in the stature of most populations. However, the American experience is puzzling in this regard: after being the tallest in the world for two centuries (Komlos, 2001) the US population appears to have stopped growing for two decades during the middle of the 20th century (Komlos & Baur, 2004; Komlos & Lauderdale, 2007a, b). Because most Western and Northern European populations continued to grow, the height of the US population declined relative to that of many industrial nations. Most European populations grew by about 1 cm per decade in the last century and a half. 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 the next 250 years (A'Hearn, 1998; Cole, 2003; Komlos & Baur, 2004). As a consequence, Dutch men born in the 1940s had overtaken their US counterparts in height, while Germans, Danes, Norwegians and others followed in the 1950s and 1960s. Today, Swedes, Czechs, Finns, Belgians and Canadians are all taller than the US population, even if one excludes Hispanics, Asians and foreigners from the American averages (Komlos & Kriwy, 2002; Sunder, 2003; Komlos & Lauderdale, 2007a).

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 analysing the secular trend in the height of the US population (Ogden, 2004; Komlos & Baur, 2004; Komlos & Lauderdale, 2007a, b) are relying on surveys that include only broad information on the race/ethnicity 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. Reliable evidence on the height of the US population is scarce. The only representative data available to the author's knowledge is limited to the NHANES data sets, but they collect no information on the parents of the adults examined. As a consequence second-generation effects cannot be controlled for. Ethnicity of the subject is not always recorded. These omitted variables could well affect the estimated trends. The Anthropometric Survey of US military personnel in 1988 (ANSUR) is therefore used. This carefully conducted survey allows the exploration of effects of ethnicity of the subject and that of his/her parents, as well as the place of birth of the parents. These variables are not available in the NHANES surveys and therefore the ANSUR data set allows this effect to be examined among US army personnel. While the full ANSUR database includes measurement of 132 anthropometric dimensions (Clauser *et al.*, 1988; Gordon *et al.*, 1989), the extract available for this study includes only mean stature and weight. Even though army personnel are not representative of the US population as they are drawn rather from mostly lower segments the society, the data are nonetheless important on account of the scarcity of comparable evidence.

Previous research on the secular trend in US mean stature

Komlos & Baur (2004) analysed NHANES III survey data, collected between 1988 and 1994. They were the first to show that the height of US-born men and women stagnated among the cohorts born in the 1950s and that the US had fallen behind in height for the first time in its history. Komlos & Lauderdale (2007a) expanded upon these results using combined NHES and NHANES I–IV samples to more accurately identify the trends of US-born non-Hispanic white and black adults stratified by gender. They found that both male and female heights remained unchanged between those born circa 1955 and 1975. Black female heights have remained unchanged since the 1925 birth cohorts. Black males alone showed steady improvement over time, catching up with their white counterparts, but still below Western European norms. Results indicating a more recent increase in height among whites born between 1975 and 1983 are based on a small number of observations and therefore need to be considered preliminary. This result has been further corroborated, in the main, by Komlos & Lauderdale (2007b) using data of a commercial (non-random) US survey.

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

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Table 1. Composition of the sample

	Females	Males	Total
Whites	1148	1338	2486
Blacks	1141	1235	2376
Hispanics	176	520	696
Asian	30	81	111
Other	190	374	564
Total	2685	3548	6233

Source: ANSUR database.

et al., 1989). Hence, the data being analysed are neither representative of the US population nor of the US military forces. The data set contains information on the stature, weight and sex of the subject as well as birthplace, and racial and ethnic background of the subject and his/her parents. The data set contains 8537 observations, pertaining to subjects born between 1940 and 1970. Of these, 1369 were immigrants who were excluded from the analysis. The analysis was further limited to adults. In modern populations, maximum height is reached – on average – at the age of 18–19 for boys and two years earlier for girls (Tanner & Whitehouse, 1976; Hamill *et al*., 1977; van Wieringen, 1979; Marshall, 1979; Bogin, 1999; Kuczmarski, 2000). The exact timing of the age heights begin to decline is still debated. Some studies suggest that the decrease begins already at the age of about 30 to 35, but remains minimal until about 40 and becomes more noticeable past the age of 50 (Friedlaender *et al*., 1977; Cline *et al*., 1989; Galloway *et al*., 1990). Van Wieringen (1979) 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. To be on the safe side, only adults in the age from 20 to 43 are included in the analysis. This limitation reduces the data set by another 935 observations, so the analysis is based on the 6233 US-born members of US Army personnel (Table 1). Unfortunately, in a cross-sectional data set such as the ANSUR it is not possible to distinguish between age and cohort effects as these are collinear. However, the amount shrinking past age 35 is rather small. Even if it were substantial it would make the trends steeper than they should be. As a positive trend is not found below, this effect could not have been large. Also, adding dummy variables for younger ages (20, 21 and 22 years) did not yield significant estimation coefficients. Hence, these controls were excluded from the estimation models.

The analysis focuses on non-Hispanic whites and non-Hispanic blacks as the small number of observations in the other ethnic groups prohibits meaningful analysis (hereafter the designation non-Hispanic is dropped and these groups are referred to as just whites and blacks). 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 small number of black soldiers reported to be of Latin American

Fig. 1. Census regions and divisions of the United States.

ethnicity. People who did not feel that they or their parents belonged to a distinct ethnic group identified themselves plainly as Americans, while people who identified themselves as of mixed background were coded unknown.

It is not know when the measurements were taken. 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 data set is that it provides self-identified information on the ethnicity (obtained in an interview, see Clauser *et al.*, 1988) and place of birth of both the subject and his/her parents that is not available in the NHANES surveys. Self-identified information introduces 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 a consequence of being a hybrid of different ethnicities) used this classification. The number of observations for all the variables used in the analysis is shown in Table 2.

In spite of its advantages, the ANSUR database also has some shortcomings as it does not include information on such well-established correlates of physical stature as the level of education and the economic background of the subjects (for a discussion of the impact of these factors, see Komlos, 1994). 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 US Bureau of the Census classification (see Fig. 1 for an overview map).

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Table 2. Ethnic and spatial composition of the sample

	White females (*n*)	White males (*n*)	Black females (*n*)	Black males (*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

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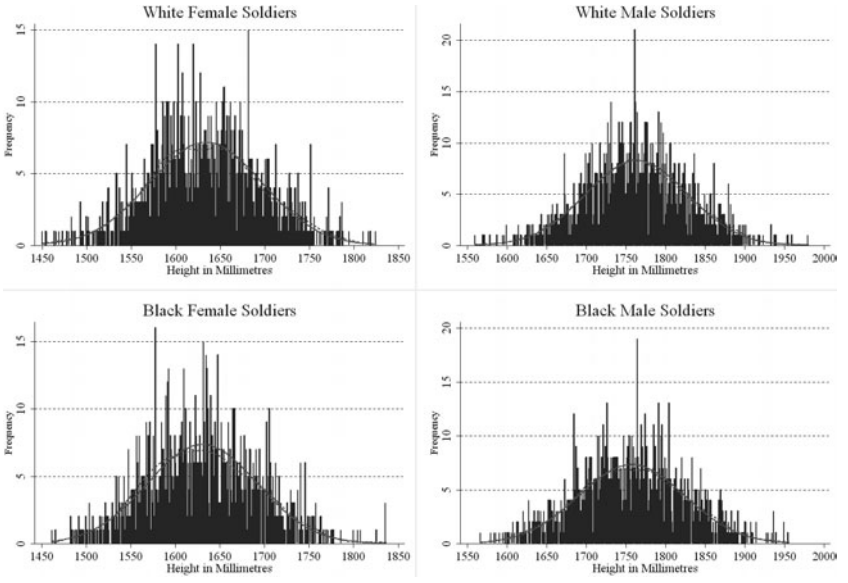

Fig. 2. Histograms of stature of US Army personnel.

A visual inspection of the distribution of the heights for normality is required prior to any regression analysis, as the US military imposes certain height requirements (see Gordon & Friedl (1994) for an extensive discussion of the anthropometric requirements imposed by the different US military services) (see Fig. 2). The US 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 & Rowland (1987) report that the range from the 1st to the 99th percentile in the NHANES II sample is 62·6 to 75·6 inches (159·0 to 192·0 cm) for males and 57·6 to 69·7 inches (146·3 to 177·0 cm) for females. Hence, the enlistment restrictions of the military affect much less than the bottom 1% or top 1% of the US adult population. Thus, the data can be treated as normally distributed and are analysed using OLS regressions. However, there appears to be heaping on some numbers. For instance, there are fourteen white females with a measured height of 162·0 cm, but only three (five) subjects with a height of 161·9 cm (162. 1 cm) are reported. While this is a typical case of rounding towards nearby even numbers, other cases seem to be random: there are fifteen females with a height of 168·2 cm, while the neighbouring values of 168·1 and 168·3 cm list only four and six observations, respectively. Yet, systematic rounding does not introduce a significant bias, since upward and downward rounding tends to cancel each other (Komlos, 2004) and should not distort the estimation results.

The body mass index (BMI, defined as weight (in kg) over stature (in m) to the power of two) of the soldiers is also analysed (Fig. 3). The US military also imposes requirements regarding weight at the time of enlistment. There are height- and

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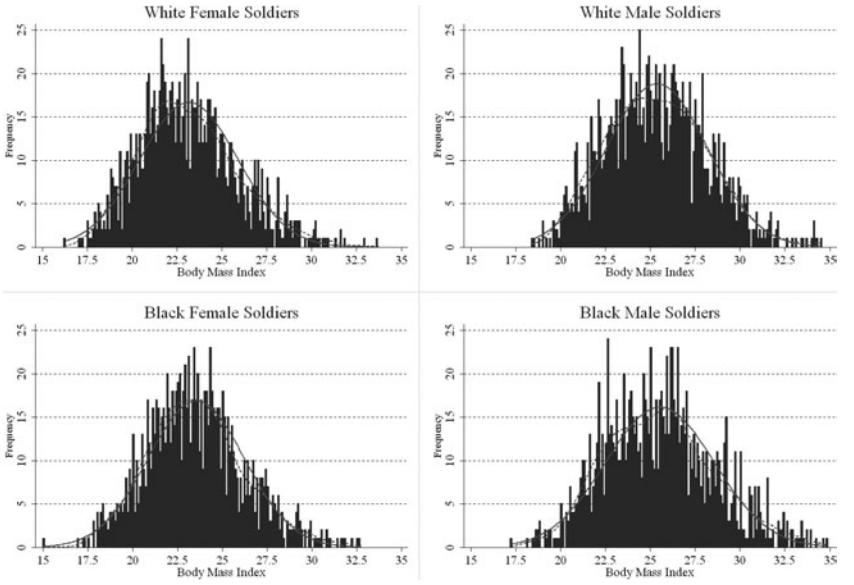

Fig. 3. Histograms of BMI of US Army personnel.

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). In case 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. While Flegal *et al*. (2002) report a prevalence of obesity among 20- to 39-year-old men of 14·9%, and a prevalence of 20·6% among females based on the NHANES III data, in the current sample (which also includes 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 time of entry, and more importantly, the nature of the daily work of soldiers.

For the analysis of physical stature, the sample is divided into four different subsets stratified by race and sex. The basic Model 1 uses only the dummy variables for the quinquennium of birth and a control variable of 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 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 his/her parents. In the analysis of BMI, the data are stratified in the same manner, but only Model 6 is employed in the regression analysis. In order to control for potential effects specific to subjects with foreign-born parents, estimations including dummy variables for parents (mother/

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Table 3. Height of US-born white female soldiers, aged between 20 and 43

Variable	Model 1	(SE)	Model 2	(SE)	Model 3	(SE)	Model 4	(SE)	Model 5	(SE)	Model 6	(SE)
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	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
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	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
Subject's ethnicity												
American			Ref.		Ref.		Ref.				Ref.	
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					Ref.						Ref.	
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							Ref.				Ref.	
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									Ref.		Ref.	

Table 3. *Continued*

Variable	Model 1	(SE)	Model 2	(SE)	Model 3	(SE)	Model 4	(SE)	Model 5	(SE)	Model 6	(SE)
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	1626·99***	(4·68)	1624·78***	(4·99)	1623·59***	(5·97)	1624·97***	(5·77)	1627·39***	(5·78)	1624·60***	(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 millimetres. Robust standard errors (SE) in parentheses.
*Significant at the 10% level;**significant at the 5% level; ***significant at the 1% level.
Source: ANSUR database.

Table 4. Height of US-born white male soldiers, aged between 20 and 43

Variable	Model 1	(SE)	Model 2	(SE)	Model 3	(SE)	Model 4	(SE)	Model 5	(SE)	Model 6	(SE)
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	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
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	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
Subject's ethnicity												
American			Ref.		Ref.		Ref.				Ref.	
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					Ref.						Ref.	
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							Ref.				Ref.	
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									Ref.		Ref.	

Table 4. *Continued*

Variable	Model 1	(SE)	Model 2	(SE)	Model 3	(SE)	Model 4	(SE)	Model 5	(SE)	Model 6	(SE)
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	1762·32***	(4·63)	1761·00***	(4·89)	1757·14***	(5·37)	1759·48***	(5·29)	1760·39***	(6·04)	1757·10***	(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 millimetres. Robust standard errors (SE) in parentheses.
*Significant at the 10% level; **significant at the 5% level; ***significant at the 1% level.
Source: ANSUR database.

Table 5. Height of US-born black female soldiers, aged between 20 and 43

Variable	Model 1	(SE)	Model 2	(SE)	Model 3	(SE)	Model 4	(SE)	Model 5	(SE)	Model 6	(SE)
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	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
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	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
Subject's ethnicity												
American			Ref.		Ref.		Ref.				Ref.	
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					Ref.						Ref.	
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							Ref.				Ref.	
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)

Table 5. *Continued*

Variable	Model 1	(SE)	Model 2	(SE)	Model 3	(SE)	Model 4	(SE)	Model 5	(SE)	Model 6	(SE)
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									Ref.		Ref.	
Intercept	1628·10***	(3·80)	1624·09***	(6·35)	1623·90***	(6·39)	1621·54***	(6·45)	1625·71***	(4·21)	1620·41***	(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 millimetres. Robust standard errors (SE) in parentheses.
*Significant at the 10% level; **significant at the 5% level; ***significant at the 1% level.
Source: ANSUR database.

Table 6. Height of US-born black male soldiers, aged between 20 and 43

Variable	Model 1	(SE)	Model 2	(SE)	Model 3	(SE)	Model 4	(SE)	Model 5	(SE)	Model 6	(SE)
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	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
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	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
Subject's ethnicity												
American			Ref.		Ref.		Ref.				Ref.	
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					Ref.						Ref.	
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							Ref.				Ref.	
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)

Table 6. *Continued*

Variable	Model 1	(SE)	Model 2	(SE)	Model 3	(SE)	Model 4	(SE)	Model 5	(SE)	Model 6	(SE)
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									Ref.		Ref.	
Intercept	1760·23***	(4·38)	1764·98***	(5·72)	1765·20***	(5·74)	1764·97***	(5·82)	1758·55***	(4·77)	1763·52***	(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 millimetres. Robust standard errors (SE) in parentheses.
* Significant at the 10% level; **significant at the 5% level; ***significant at the 1% level.
Source: ANSUR database.

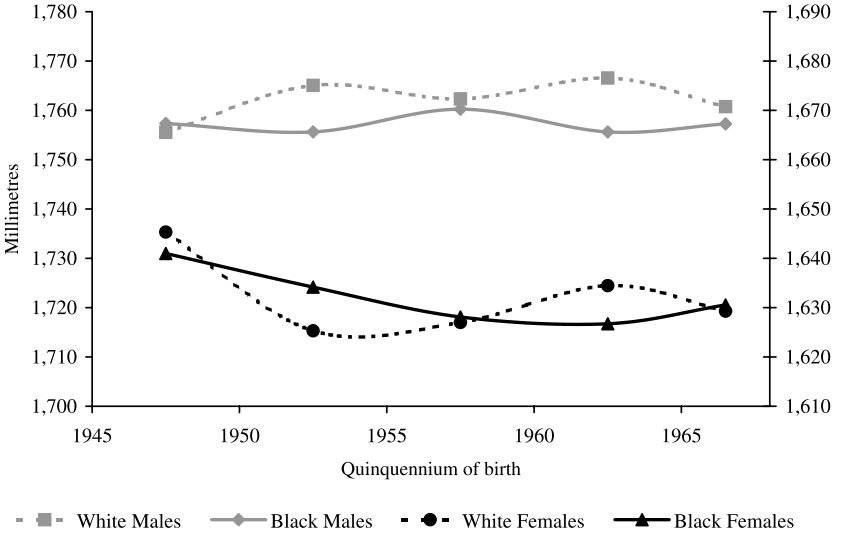

Fig. 4. Time trend in height of US Army personnel. Source: Tables 3–6. Male heights on left scale, females heights on right scale.

father/both) of foreign birth were run; however, none of the estimation coefficients turned out to be statistically significant.

Results

Stature of US military personnel

The results of the OLS regression of determinates of mean stature are shown in Tables 3–6. A plot sketching the secular trend in stature is shown in Fig. 4.

In all four subsamples, mean heights (estimated by Model 1) stagnated with slight fluctuations within the range of 1 cm for soldiers born between 1950 and 1970. Since the composition of the US Army changed subsequent to the transition to a volunteer army in 1973, the estimates for soldiers born between 1945 and 1950 are likely to represent a different subset of the population. After circa 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 in height of 0·6 cm 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. The estimated coefficient for males indicated a similar effect, but it is significant only in some specifications. The effect appears to be larger

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among blacks (1·5–1·6 cm), but remains statistically insignificant as there is only a small number of observations available for black officers ($N=40$).

The results of the ethnical information included in the regression do not show a clear pattern. For whites, Northern European ancestry appears to be associated with a slim height advantage (0·5–1·0 cm) over those who consider themselves as American. For white females, the effect 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 insignificant. The effect of the other ethnic groups used in the analysis of whites is inconclusive: the direction of the coefficient is changing in the different specifications and the directions of the parents' ethnicity are opposed to the subject's own ethnicity.

Among the black soldiers, the above-mentioned pattern of contradicting effects of ethnicity between the subject and his/her 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 are about 2 cm taller than the reference group (East–North–Central). For white males, none of the spatial dummy variables turns out to be significant. 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 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 US military personnel

The results in Table 7 and Fig. 5 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 34–38 is higher than among those five years older, and 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).

Commissioned officers appear to be a little less heavy than enlisted personnel (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 significantly among the whites, and in addition the estimated coefficients are small (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 clear: while the results show that having a Latin American mother has a positive effect on BMI of black females of 1·6 points, a Latin American father has a negative impact of –2·3 BMI points. Similarly, for black males the effect of

Table 7. BMI of US Army personnel, aged between 20 and 43

Variable	White females		White males		Black females		Black males	
Age group (years)								
39–43	1·78***	(0·54)	0·58	(0·38)	0·76	(0·64)	1·11**	(0·46)
34–38	0·62*	(0·33)	1·04***	(0·31)	1·18***	(0·31)	0·09	(0·36)
29–33	Ref.		Ref.		Ref.		Ref.	
24–28	− 0·55**	(0·24)	− 0·50**	(0·24)	− 0·63***	(0·22)	− 0·53**	(0·26)
20–23	− 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	Ref.		Ref.		Ref.		Ref.	
Subject's ethnicity								
American	Ref.		Ref.		Ref.		Ref.	
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	Ref.		Ref.		Ref.		Ref.	
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		Ref.		Ref.	
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	Ref.		Ref.		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	(0·26)	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)	Ref.		Ref.	
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/m^2. Robust standard errors (SE) in parentheses.
*Significant at the 10% level; **significant at the 5% level; ***significant at the 1% level.
Source: ANSUR database.

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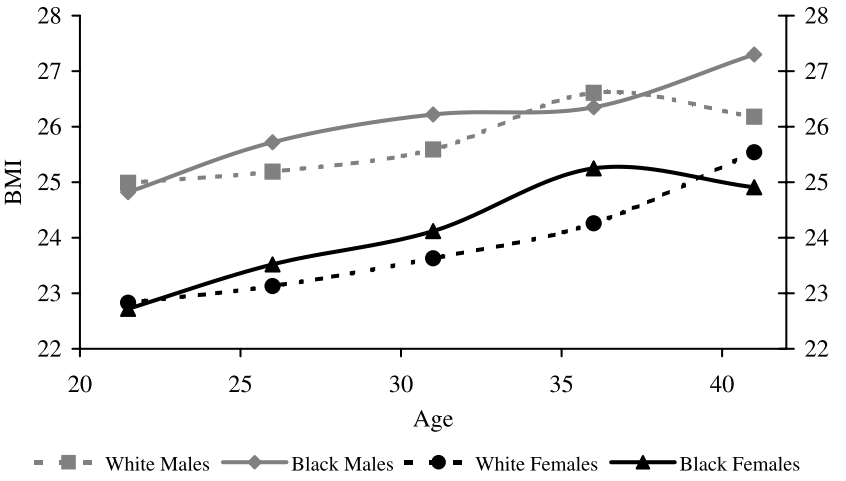

Fig. 5. Body mass index of US Army personnel. Source: estimates for Model 1 based on the ANSUR database.

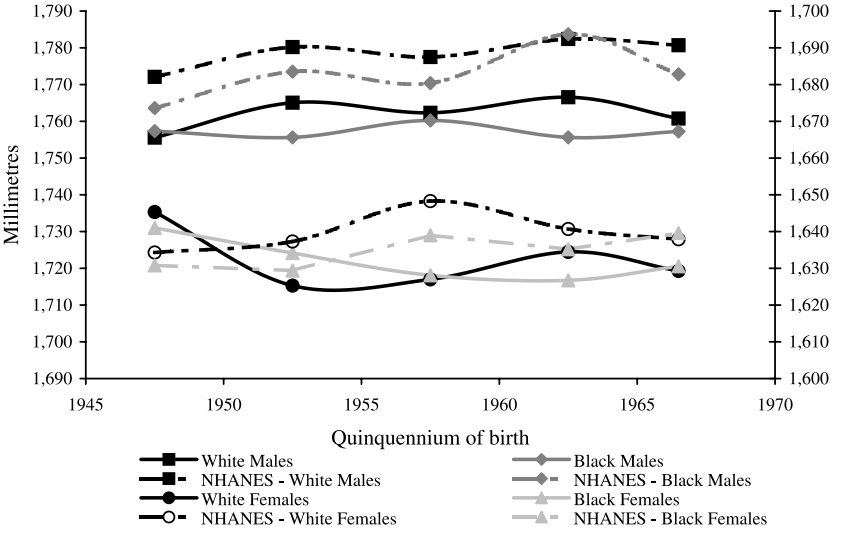

Fig. 6. Comparison of military and NHANES heights. Source: Model 1 in Tables 3, 4, 5 and 6, NHANES: Komlos & Lauderdale (2007a). Male heights are measured on left scale, female heights on right scale.

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.

There are some spatial effects in the regressions, yet there is no meaningful pattern apparent. 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

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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 those born in the East–North–Central division. Soldiers born in the Mountain states are 0·66 lighter.

In both of the black subsets, none of the regional estimates are 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 birthplace on body mass is rather negligible.

Discussion

The analysis of the ANSUR data set indicates that heights of US 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. A height gradient by socioeconomic status, proxied by military rank, is a robust finding. Ethnicity of both the subject and his/her parents 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 merely as American. This is also the only result for which the influence of the subject's and his/her 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 analysed by race but without controlling for exact ethnicity, this result validates the usual method of analysis: ethnicity does not affect the levels or trends in height meaningfully.

For validation of the results obtained, the estimated heights of the US Army personnel are compared with the estimates of the NHANES survey. 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 & Baur, 2004; Komlos & Lauderdale, 2007a). In comparison to NHANES data, there are some differences in the level of height, with the US Army personnel being somewhat shorter (about 1·4–1·7 cm on average among males and a little less among females). This is an indication that the ANSUR database describes subjects that originate from a poorer or less educated segment of the US 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 in general supported by both data sets. Thus, the ANSUR data support the conclusion reached in Komlos & Lauderdale (2007a) that US heights tended to begin to stagnate shortly after World War II. The results obtained with the NHANES data sets are not caused by omitting variables pertaining to second-generation effects, including foreign birth.

This stagnation during the golden age of economic growth is quite puzzling considering the rapid increases in *per capita* income. Apparently, increases in income did not translate into physical growth, while in Europe it did. This led to a relative decline in comparison to other Western populations. Potential explanations for this phenomenon include the large social inequality in the US, inefficiencies in the US

health care system, the less comprehensive social safety net (including health insurance) and larger spatial differences in the US (Komlos & Baur, 2004; Komlos & 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 & Lauderdale 2007a). A comparison of the levels and prevalence of obesity between the US Army personnel and the civilian population shows that the military personnel are 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 US Army soldiers corroborates that physical stature stagnated in the US for some time after World War II. The stagnation among this lower status segment of the society is not influenced by changes in the ethnic composition, as neither the subject's own ethnicity nor his parents' ethnicity has a significant impact on the subject's physical stature. Spatial difference between census divisions in the United States could not be observed. Thus, changes in the ethnic and spatial composition of the data are unlikely to account for the relative decline in stature observed in the US civilian population. The lack of influence of ethnicity and place of birth can also be observed with respect to BMI. These results strengthen the trends found in the NHANES data sets, and suggest that those trends were most probably not biased by the omitted variables pertaining to own ethnicity or second-generation effects of parents' ethnicity or foreign birth.

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