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Abstract

Secular change in height has been extensively investigated, but size and shape of the postcranial skeleton much less so. The availability of large, documented collections of 19th and 20th century skeletons makes it possible to examine changes in skeletal structure over the past 150 years. In this, paper we examine secular changes in long bone lengths and proportions, their allometric relationship to stature, and cross sectional properties of long bone shafts.

Bone measurements and stature were organized into 10 year birth cohorts, ranging from 1840 to 1989. Variation among cohorts was tested by one way ANOVA and secular trend was examined visually by plotting mean measurements by birth decade. Allometry was examined by regressing log bone lengths onto log stature, using least squares regression. Allometry was also examined using the geometric mean of log bone lengths as the size variable.

All bone lengths and stature show positive secular change. Stature and the distal long bones show the most pronounced changes. There are also changes in proportions as revealed by the brachial and crural indices. Both indices increase, but the brachial index change is the most pronounced. Allometric relationships suggest that brachial index changes result from positive allometry of the radius and negative allometry of the humerus. Similar but less marked allometric relationships are seen in the tibia and femur. Long bone shaft properties change in the following ways: femur midshafts and tibia shafts at the nutrient foramen became more medio-laterally narrowed; the femur becomes more medio-laterally thickened at the subtrochanteric level, approaching platymeria. All major long bones become more gracile.

These remarkable changes in the postcranial skeleton are a response to the unparalleled changes in the environment in which modern Americans now live. Changes in growth resulting from plentiful and secure nutrition, reduced disease load, and marked reduction in bone loading from reduced activity levels are mainly responsible.

Secular change in stature has received considerable attention in the U.S. and Europe (Floud et al. 2011; Komlos 1995, Fogel 2004). From an anthropological perspective, changes in stature reflect changes in long bone length. However, observing secular trends in long bone length has been limited by the lack of availability of modern skeletal collections. Trotter and Gleser (1951) realized the importance of bone length as an indicator of secular change. Only the Terry collection and the World War II sample were available, so their time frame was limited to birth cohorts from 1840 to 1924. Nevertheless, they were able to show a relatively steep change occurring in the early 20th century. In the past three decades, much more skeletal data has become available and has been used to investigate a much longer time series of long bone lengths (Meadows Jantz and Jantz 1999).

Skeletal analyses possess some significant advantages in the study of secular changes. They permit analysis of changes in proportion, and it is not necessary to correct for changes due to ageing. Additionally they allow analyses of populations beyond the reach of historical data. Over the last 150 years the American environment has experienced tremendous change in terms of healthcare, nutrition, sanitation, and daily activity levels; all of which play significant roles in changes in our skeletons. This paper will examine secular trends in limb lengths and proportions, postcranial robusticity, shape of long bone shafts, and femoral and humeral head diameters. It will also examine whether limb proportions change in relation to stature, termed allometric changes, or whether limb proportions remain constant with changes in stature, termed isometry.

Materials and Methods

The sample of American whites is derived from three sources, including the Terry Collection, World War II casualties, and the Forensic Data Bank (FDB). Dates of birth range from the 1840s through the 1980's. Measurements for the Terry and WWII long bone lengths were performed by Mildred Trotter (Trotter and Gleser 1952). The remaining data derive from the FDB. Forensic anthropologists from across the United States submit osteometric data to the FDB (Moore-Jansen et al., 1994). The FDB also includes data from the Bass Donated collection. It is obvious that many different observers were involved in the creation of this data base. Despite measurement definitions and illustrations presented in Moore-Jansen et al. (1994, and previous editions), which most observers who contributed to the FDB used as a guide, interobserver variation is inevitable. An extensive interobserver variation study is included in the revised version of this manual (Langley et al. 2016). Variation among four observers was well below 1 % for nearly all dimensions included in this study.

Tables 1 through 3 provide the sample sizes for the long bone lengths, indices, and joint sizes for males and females by decade of birth cohort. Trotter's WWII and Terry Collection data did not include diaphyseal or joint measurements. These data for the Terry Collection were obtained from http://anthropology.si.edu/cm/terry.htm. Measured stature was available from Trotter and Gleser's WWII data, and cadaver stature was available from the Terry Collection. In addition, forensic stature (Ousley 1995) was available for many of the FDB skeletons, so stature was also included to evaluate allometric changes in bone lengths. Measured and cadaver statures were adjusted to maximum stature as described by Cline et al. (1989). Forensic stature was not adjusted because it is essentially a form of reported stature, which tends to be an overestimate of measured stature (Willey and Falsetti 1991).

Although Trotter and Gleser's (1952) definition for tibia length has been followed for the Terry and FDB data, it has been determined that Trotter did not actually measure the tibia in the way she describes (Jantz et al. 1995), which is essentially condylar-malleolar length given in Martin and Knussmann (1988) as tibia measurement number 1. Rather, she omitted the malleolus, despite saying it should be included. Therefore, Trotter's measurements have been adjusted as described in Jantz et al. (1995) to account for this discrepancy.

In addition to lengths, some diaphyseal and articular surface dimensions were also included: humerus epicondylar breadth and head breadth, humerus diaphyseal midshaft maximum and minimum diameters, femur head breadth and diaphyseal anterior-posterior and mediolateral diameters at the subtrochanteric and midshaft levels, and tibia anterior-posterior and medio-lateral diameters at the nutrient foramen level. These measurements were taken as defined in Moore-Jansen et al. (1994).

Several indices were also used to quantify various aspects of limb proportions and diaphyseal shape and robusticity. The brachial index (radius length/humerus length x 100) and crural index (tibia length/femur length x 100) show proportions of distal and proximal segments of upper and lower limbs respectively. Indices of robusticity were calculated as √((a-p) x (m-l))/length. Robusticity in the humerus was calculated using the maximum and minimum midshaft diameters in place of a-p (antero-posterior) and m-l (medio-lateral) dimensions. Diaphyseal shapes at the subtrochanter of the femur (platymeric index) and the nutrient foramen of the tibia (cnemic index) were expressed as (a-p/m-l) x100. Lovejoy et al. (1976) present the cnemic index as (m-l/a-p) x100. Our definition is therefore the inverse of the traditional definition, but maintains consistency with other indices in placing a-p in the numerator.

Variation among decade cohorts was tested using one way ANOVA in NCSS10 (2015). Secular changes were evaluated visually by plotting mean lengths for each 10 year cohort. Allometry of bone lengths in relation to size was investigated by regressing log bone length onto log stature, using least squares regression in NCSS10 (2015). We also evaluated variation in sexual dimorphism by dividing the sample into three broad groups, defined as mid to late 19th century (birth years 1850-1899), early 20th century (birth years 1900-1949) and late 20th century (birth years 1950-1989). Sexual dimorphism was evaluated using 2-level ANOVA in NCSS10 (2015), with sex and time group as treatments. The interaction of group*sex tests for variation in sexual dimorphism (Konigsberg 1991).

Results

Long Bone Lengths

Table 4 shows the ANOVA tests for variation among decade means of the long bone lengths, stature, and the crural and brachial indices. Males are more variable than females as demonstrated by the F ratios. Males exhibit patterning in variation between upper and lower limbs, and proximal and distal elements within both upper and lower limbs to a greater extent than females. Proximal bones are less variable than distal bones, and upper limb bones are less variable than lower limb bones. Brachial indices are more variable than crural indices. The crural index shows relatively longer tibiae in males, but not females. The brachial index is larger than the crural index in both sexes, but in males it has the highest F ratio of all bone related variables. Male stature is the most variable.

The variability among birth cohorts reflects little about how it is patterned. Figure 1 shows the mean lengths by birth cohort of the four main long bones (humerus, radius, femur and tibia) for males and females. Stature is illustrated in Figure 2 with crural and brachial indices presented in Figure 3. In general, the long bones exhibit increases in length beginning just before the turn of the century. Females have less marked trends, and more apparent stochastic variation because of smaller sample sizes. Both sexes demonstrate an increase in stature from the mid-19th century through the late 20^{th} century, with males increasing faster than females. Males exhibit an especially marked increase in stature in the 20^{th} century. While females also increase in stature across this time, it is not as striking. The brachial index shows a steady increase with males out pacing females. The crural index also increases, but with less regularity than the brachial index.

The changing indices document proportional change, so we can inquire whether these are due to allometric responses to increases in stature. Table 5 shows the scaling coefficients of each long bone in relation to stature. In males, the humerus, radius, and ulna are negatively allometric, but the femur does not differ from isometry, and the tibia and fibula are positively allometric. In females all upper limb bones and the femur are negatively allometric, and tibia and fibula do not differ from isometry. The male scaling coefficients indicate that the humerus becomes relatively shorter in relation to stature, while the radius is closer to isometry. This in turn implies that changes in the male brachial index are due to relatively shorter humeri rather than to relatively longer radii. In females, all bones are negatively allometric except for the tibia and fibula, which are isometric. The humerus is considerably more negatively allometric than the radius, suggesting, as in males, that the humerus becomes shorter relative to the radius with increasing stature.

Secular changes in male crural index are presumably due to positive allometry of the tibia and isometry of the femur. The pattern of change of the male crural index is similar to that seen in the tibia, supporting the idea that the tibia is driving the change in crural index in males. The female pattern differs somewhat from the male pattern, where the tibia and fibula are isometric and the femur is negatively allometric. Both female femur and tibia show weak positive trends; crural index shows little evidence of trend. Apparently the more or less parallel changes in femur and tibia maintain proportionality as seen in the crural index, despite what the scaling coefficients might suggest.

Some additional insight into allometric changes may be obtained from using size defined by the bones themselves, rather than stature. Table 6 shows the scaling coefficients obtained from regressing each bone on mean log size, as suggested by Jolicoeur (1963). This approach imposes certain constraints on the allometry coefficients in that their average must be 1, since size is internally defined (Auerbach and Sylvester 2011). In males, all bones differ significantly from isometry, and all are negatively allometric with the exception of the tibia. The tibia is positively allometric in females. The female humerus is negatively allometric, while the femur and radius are isometric. Both sexes agree in showing strong negative allometry for the humerus compared to the radius.

Meadows Jantz and Jantz (1999) observed that female secular change is not as pronounced as male change. This is also implied by the lower variation among birth year cohorts in Table 4. The change in males is more marked than in females, which leads to the expectation that sexual dimorphism increases. Sex and time group interaction F ratios are shown in Table 7. They reveal that all bones, stature, and both indices change in sexual dimorphism from the 19th to the 20th century. Specifically, stature dimorphism increases by more than 3 cm from the late 19th to early 20th century and continues to rise into the late 20th century. The long bones similarly increase from the late 19th to early 20th century, but unlike stature, this trend does not continue through the latter part of the 20th century.

Long Bone Size and Shape Properties

Variation for size and shape properties of long bone shafts and proximal articular surfaces among decade birth cohorts was examined using variables that describe various aspects of diaphyseal shape, robusticity, and head diameters for the humerus and femur. Table 8 presents the

ANOVA tests for variation for size and shape properties of long bone shafts and proximal articular surfaces among decade birth cohorts. For the humerus, the variables which show significant variation (alpha < 0.05) among decade birth cohorts for males are head diameter and epicondylar breadth. Among females however, the only variable to show significant variation among decade birth cohorts is humerus robusticity. Femoral head diameter is significant only for males. All of the shape and robusticity indices for femur and tibia are significant for males. Over time, females show significant variation in lower limb midshaft shape and robusticity with the exception of tibia robusticity.

Figure 4 illustrates the robusticity change over time. In the 19th century, males show an increase in all bones, however, during the 20th century, all bones, especially the femur and tibia, show a decline in robusticity over time. Females show a general decline throughout both 19th and 20th centuries. Both femur and tibia experience a marked reduction in sexual dimorphism, although males remain more robust throughout the time period represented. Figure 5 shows the humerus and femur head diameter change. A trend is barely apparent and decreases significantly only in males.

Figure 6 shows the index of platymeria and midshaft shape. The secular change for these variables proceeds in opposite directions with platymeria decreasing and midshaft shape increasing. The cross sectional shape reflected by these two indices is nearly round in the mid 19th century. From 1880 to 1910, these indices diverge with subtrochanteric dimensions becoming more platymeric, while the midshaft index moves toward greater relative anterior-posterior elongation. Although the pattern shift is towards playtmeria, the population remains in the euromeric range (Wescott 2005).

The cnemic index shown in Figure 7, presents a notable pattern characterized by a steep rise in the index at the turn of the century. Like the femur midshaft index, this is mainly due to mediolateral narrowing.

Discussion

The results show clearly that the postcranial skeleton has undergone some rather remarkable restructuring since the turn of the 20th century. Stature shows stronger trends than any of the long bones, which implies trunk height is also experiencing secular trend. Our stature data agree well with what has been presented by Floud et al. (2011) from historical records. Changes in relative long bone lengths can largely be seen as allometric responses to increasing size. The strong negative allometry of the humerus can be seen as the driving forces behind the increasing brachial index, as can the greater positive allometry of the tibia compared to the femur regarding the crural index. This was also seen in the decline of relative length of the humerus over time (Meadows Jantz and Jantz 1999).

Auerbach and Sylvester (2011) have argued that when using stature as a size variable, all bones exhibit positive allometry. Our current results do not support that conclusion. However, the WWII sample (Meadows and Jantz 1995) found positive allometry in all bones except the ulna, but that was not the case for the 19th century Terry sample. This begs the question of whether allometry itself varies in time. We calculated the allometry coefficients for the male sample for late19th, early 20th and late 20th century samples. The proximal bones became more negatively allometric through time, while the distal bones did not vary systematically. This requires further investigation, but may suggest that growth gradients are themselves subject to secular change and interpopulation variation.

One of the more remarkable secular changes concerns the brachial index. In the early 19th century, it is approximately equal to the Neanderthals in Holliday (1998), while by the end of the 20th century it is about the same as his Upper Paleolithic and Mesolithic groups, the most distally extended of his European groups. The crural index is more constrained, ranging from about 81 to 83, well within the European range, the higher value about equal to Holliday's recent Europeans. It is reasonable to suppose that locomotor functions constrain the crural index, while the brachial index is less constrained and can respond to changes in activity.

Changes in cross sectional morphology are also remarkable. In general, one sees linearization and gracilization of the long bones. The femur midshaft and tibia at the nutrient foramen became relatively narrower. Robusticity decreases markedly, especially in the femur and tibia. Looking at determinants of long bone geometry broadly, several factors have been identified as playing a significant role, among them climate (Pearson 2000), activity (Shaw and Ruff 1987; Stock 2006; Wescott 2006), body breadth (Davies and Stock 2014), body weight (Reeves 2013; Ruff et al. 1991), muscle strength (Frost 1997) and lower limb length (Shaw and Stock 2011). Climate would seem to play a limited role in the present results, so other alternatives must be considered.

The most obvious changes relevant to long bone cross sectional morphology involve a major reduction in activity, especially work related activity (Floud et al. 2011) resulting from increased mechanization. Reducing childhood labor from child labor laws was also likely an import factor because it would have reduced stress on the developing skeleton. Linearization and gracilization take the form of reduced medio-lateral dimensions of the femur midshaft, something noted by Trotter et al. (1968), and of the tibia at the level of the nutrient foramen. Shaw and Stock (2009) have shown that tibia shape and robusticity respond to activity level and directionality of loading. The medio-lateral narrowing and reduction in robusticity presumably reflect reduction in multidirectional loading associated with physical labor and overall reduction in activity beginning at the turn of the 20th century and continuing throughout the 20th century.

Ruff et al. (1991) present evidence that the medio-lateral expansion of the proximal femur is associated with body weight. Body mass index (BMI) rises from 1870 to 2000 (Floud et al. 2011). That may account for the trend toward platymeria seen in Figure 6, but large increases in BMI associated with the past few decades do not seem to be reflected in the index, which is essentially flat after about 1920. Hypertrophy of the proximal femur was also found to be associated with body breadth (Davies and Stock 2014). However, body breadth has been shown to decrease from the 19th to 20th century (Driscoll 2010).

Conclusion

Much of the recent research on limb lengths, proportions, and cross sectional morphology is not really relevant to interpreting the restructuring of the modern postcranial skeleton. Most of them use samples from earlier populations and reflect the more stable conditions of the past. By contrast, modern Americans have experienced environmental changes far exceeding the rate and magnitude of anything that has happened in the past. The environment of modern Americans can only be described as novel, never before having been experienced by human populations. The secular changes in stature described by economic historians are seen to be the tip of the iceberg, in the sense that the entire skeleton has been restructured as a response to the new environment. The way various aspects of this new environment have influenced the changes we have seen, and possibly others we have not, are not clear. But they offer the opportunity to develop new models that explain a broader range of environments than heretofore.

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Table 1. Sample sizes by element.

	Males							Females						
Decade of Birth	Humerus	Radius	Ulna	Femur	Tibia	Fibula	Max Stature	Humerus	Radius	Ulna	Femur	Tibia	Fibula	Max Stature
1840	15	15	15	15	15	15	8	4	3	3	3	3	3	4
1850	50	50	49	48	50	50	34	20	19	19	20	20	19	16
1860	78	78	78	78	78	78	77	47	45	44	46	47	45	30
1870	74	74	74	74	74	74	73	18	16	15	19	19	16	14
1880	52	52	52	52	52	52	52	14	13	13	14	14	13	10
1890	23	23	23	22	23	23	20	6	5	5	6	6	6	4
1900	59	54	54	58	62	57	49	19	19	19	18	18	18	9
1910	499	488	473	496	496	443	477	58	55	59	53	56	51	30
1920	741	735	713	733	738	670	697	75	71	70	69	71	70	45
1930	194	193	193	177	187	189	127	78	76	74	74	78	75	61
1940	206	206	207	203	201	201	153	94	92	90	91	92	90	70
1950	205	195	198	205	201	194	143	95	90	91	91	93	90	76
1960	89	86	87	86	85	86	55	66	63	62	59	62	60	48
1970	36	34	33	35	32	27	24	40	35	34	36	33	32	27
1980	10	10	10	10	10	10	5	3	2	2	5	2	2	4

Table 2. Male sample sizes for various indices and joint dimension.

Decade of Birth	Crural Index	Brachial Index	Humeral Head Diameter	Humerus Epiphyseal Breadth	Humerus Robusticity	Femoral Head Diameter	Platymeric Index	Femur Midshaft Shape	Femur Midshaft Robusticity	Cnemic Index	Tibial Nutrient Foramen Robusticity
1840	15	15	14	14	14	13	14	13	13	13	13
1850	48	50	34	34	34	32	32	31	31	33	33
1860	78	78	11	11	11	9	9	9	9	10	10
1870	74	74	9	9	9	8	8	8	8	7	7
1880	52	52	5	5	5	5	5	5	5	5	5
1890	22	23	7	7	7	5	6	7	6	7	7
1900	58	52	19	21	20	19	19	20	16	20	20
1910	489	485	44	46	46	43	44	43	40	42	40
1920	724	726	109	117	114	106	110	109	100	112	109
1930	173	191	189	198	194	187	183	175	166	191	184
1940	191	200	206	211	203	205	204	198	189	199	194
1950	193	194	201	204	203	201	205	199	193	203	195
1960	80	86	90	90	88	90	92	87	82	88	84
1970	30	33	34	35	33	30	31	31	31	31	30
1980	10	10	9	9	9	8	8	8	8	9	9

Table 3. Female sample sizes for various indices and joint dimension.

Decade of Birth	Crural Index	Brachial Index	Humeral Head Diameter	Humerus Epiphyseal Breadth	Humerus Robusticity	Femoral Head Diameter	Platymeric Index	Femur Midshaft Shape	Femur Midshaft Robusticity	Cnemic Index	Tibial Nutrient Foramen Robusticity
1840	2	3	3	3	3	3	3	3	3	2	2
1850	20	19	15	16	16	13	16	15	14	12	11
1860	46	45	28	29	29	24	28	28	27	27	27
1870	19	16	10	10	10	10	10	10	10	7	7
1880	14	13	6	6	6	6	6	6	6	6	6
1890	6	5	4	4	4	4	4	3	3	4	4
1900	17	19	15	15	15	12	13	13	13	11	11
1910	52	52	54	58	58	54	58	57	53	60	55
1920	66	70	70	73	75	71	75	74	69	77	71
1930	73	72	78	80	75	76	77	81	73	80	77
1940	87	91	91	93	93	90	89	89	86	94	89
1950	85	88	95	96	94	91	97	98	88	96	91
1960	53	59	61	61	58	59	58	56	49	59	54
1970	29	34	40	37	39	39	38	36	34	36	33
1980	2	2	3	3	3	5	5	5	5	4	3

Table 4. F ratios and probabilities testing variation among decade cohort means.

	Males		Females	
Variable	F(ndf,ddf)	P	F(ndf,ddf)	P
Maxstat	21.09(14,1979)	<0.0001	2.86(14,433)	0.0004
Humxln	4.47(14,2316)	<0.0001	2.17(14,622)	0.008
Radxln	10.95(14,2278)	<0.0001	3.47(14,589)	<0.0001
Ulnxln	10.39(14,2244)	<0.0001	2.78(14,585)	0.0005
Femxln	10.94(14,2277)	<0.0001	2.35(14,589)	0.0036
Tibxln	15.71(14,2289)	<0.0001	2.59(14,599)	0.0012
Fibxln	15.02(14,2168)	<0.0001	2.40(14,575)	0.0029
Crural Index	7.46(14,2222)	<0.0001	1.06(14,556)	0.3938
Brachial Index	16.53(14,2254)	<0.0001	4.18(14,573)	<0.0001

Table 5. Allometric scaling coefficients for bone lengths in relation to stature.

	Males			Females		
Bone	N	Scaling	se	N	Scaling	se
Humerus	1932	0.8496*	0.0194	411	0.8059*	0.0382
Radius	1905	0.9511*	0.0199	390	0.8409*	0.0424
Ulna	1872	0.8850*	0.0192	392	0.8001*	0.0424
Femur	1908	1.0222	0.0168	387	0.9121*	0.0350
Tibia	1921	1.1451*	0.0188	395	1.0032	0.0385
Fibula	1797	1.1187*	0.0185	388	0.9717	0.0391

* Indicates significantly different from isometry.

Table 6. Bone length scaling coefficients using the geometric mean as the size variable.

	Males (N=2154)		Females (N=526)	
	Scaling	se	Scaling	se
Humerus	0.9277*	0.0085	0.9278*	0.0170
Radius	0.9792*	0.0084	1.0095	0.0173
Femur	0.9799*	0.0077	0.9887	0.0149
Tibia	1.1131*	0.0078	1.0740*	0.0164

* Indicates significantly different from isometry

Table 7. Interaction terms for 2-level ANOVA (sex and half century), testing for variation in sex dimorphism.

Variable	Interaction F (ndf,ddf)	P	19th C	E 20th C	L 20th C
Humerus	11.03(2,2943)	<0.001	26.2	32.0	24.3
Radius	8.89(2, 2873)	<0.001	21.5	27.4	23.0
Ulna	11.37(2,2835)	<0.001	22.2	29.1	24.0
Femur	7.54(2,2872)	<0.001	28.1	39.2	33.4
Tibia	10.23(2,2894)	<0.001	22.2	34.6	30.6
Fibula	8.27(2,2735)	<0.001	23.9	34.9	31.0
Stature	7.91	<0.001	8.6	12.3	12.9
Crural Index	3.37(2,2785)	0.004	-0.188	0.544	0.575
Brachial Index	3.68(2,2833)	0.025	0.489	1.078	1.411

Table 8. Variation among decade of birth cohorts for size and shape properties of long bone shafts and proximal articular surfaces.

	Males		Females	
Variable	F ratio (ndf, ddf)	P	F ratio (ndf,ddf)	P
Hum Head Diam	3.15(14,996)	**<0.001**	1.66(14,558)	0.061
Hum Epi Br	1.72(14,996)	**0.047**	1.15(14,569)	0.312
Hum Robust	1.52(14,975)	0.097	2.46(14,566)	**0.002**
Fem Head Diam	3.53(14,946)	**<0.001**	0.87(14,542)	0.593
Platymeria	3.92(14,955)	**<0.001**	3.28(14,562)	**<0.001**
Fem Midshaft shp	5.97(14,928)	**<0.001**	5.60(14,559)	**<0.001**
Fem Mid Robust	5.46(14,882)	**<0.001**	2.48(14,517)	**0.002**
Tib NFshp	3.46(14,955)	**<0.001**	3.65(14,560)	**<0.001**
TibNF Robust	3.36(14,925)	**<0.001**	1.12(14,527)	0.338

Captions for Figures

Figure 1. Mean bone lengths (mm) by decade of birth. Humerus (A); Radius (B); Femur (C); Tibia (D). Males are solid lines, females are dashed.

Figure 2. Stature (cm) by decade of birth. Males are solid lines, and females are dashed.

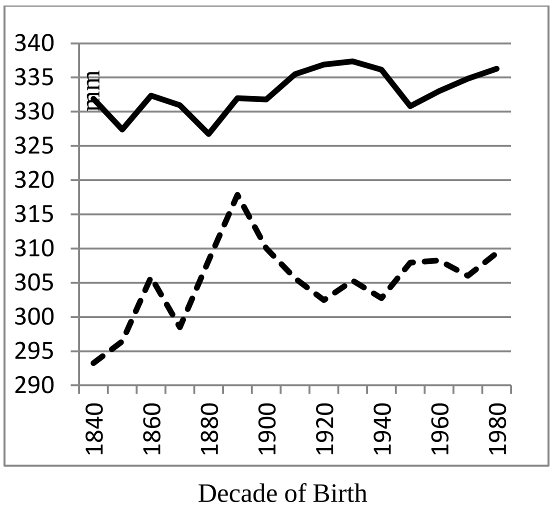
Figure 3. Indices by decade of birth. Crural (A); Brachial (B). Males are solid lines, females are dashed.

Figure 4. Robusticity by decade of birth. Humerus (A); Femur (B); Tibia (C). Males are solid lines, and females are dashed.

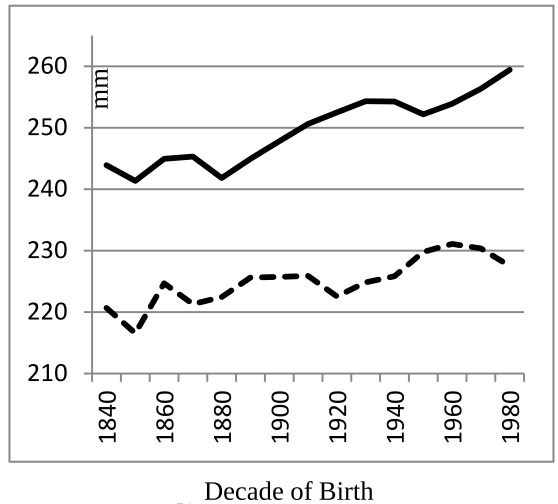
Figure 5. Humerus (A) and femur (B) head diameters (mm) by decade of birth. Males are solid lines, and females are dashed.

Figure 6. Platymeric index (A) and femur midshaft shape (B) by decade of birth. Males are solid lines, and females are dashed.

Figure 7. Cnemic index by decade of birth. Males are solid lines, and females are dashed.

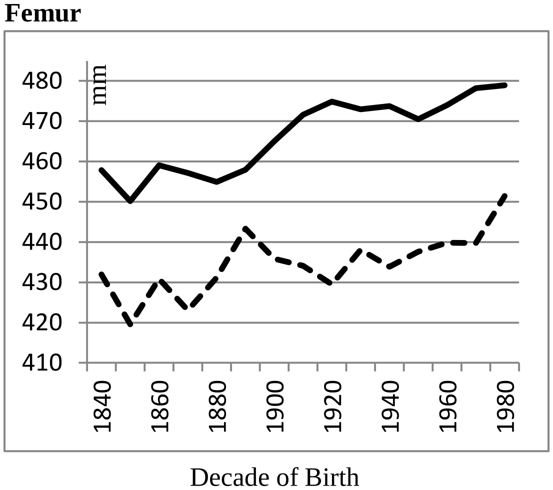


A. Humerus

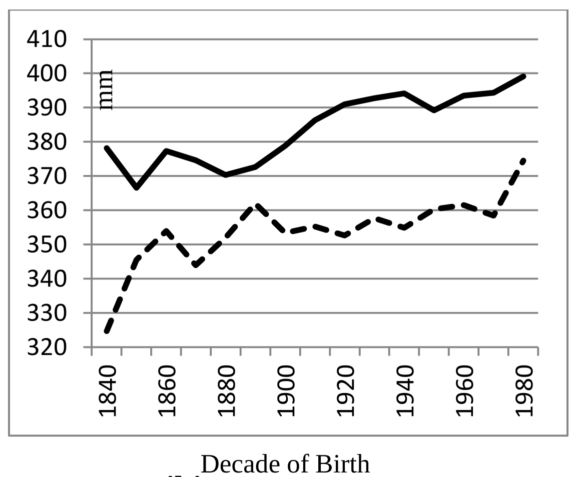


B. Radius

Femur



C. Femur



D. Tibia

Figure 1. Mean bone lengths by decade of birth. Males are solid lines, and females are dashed.

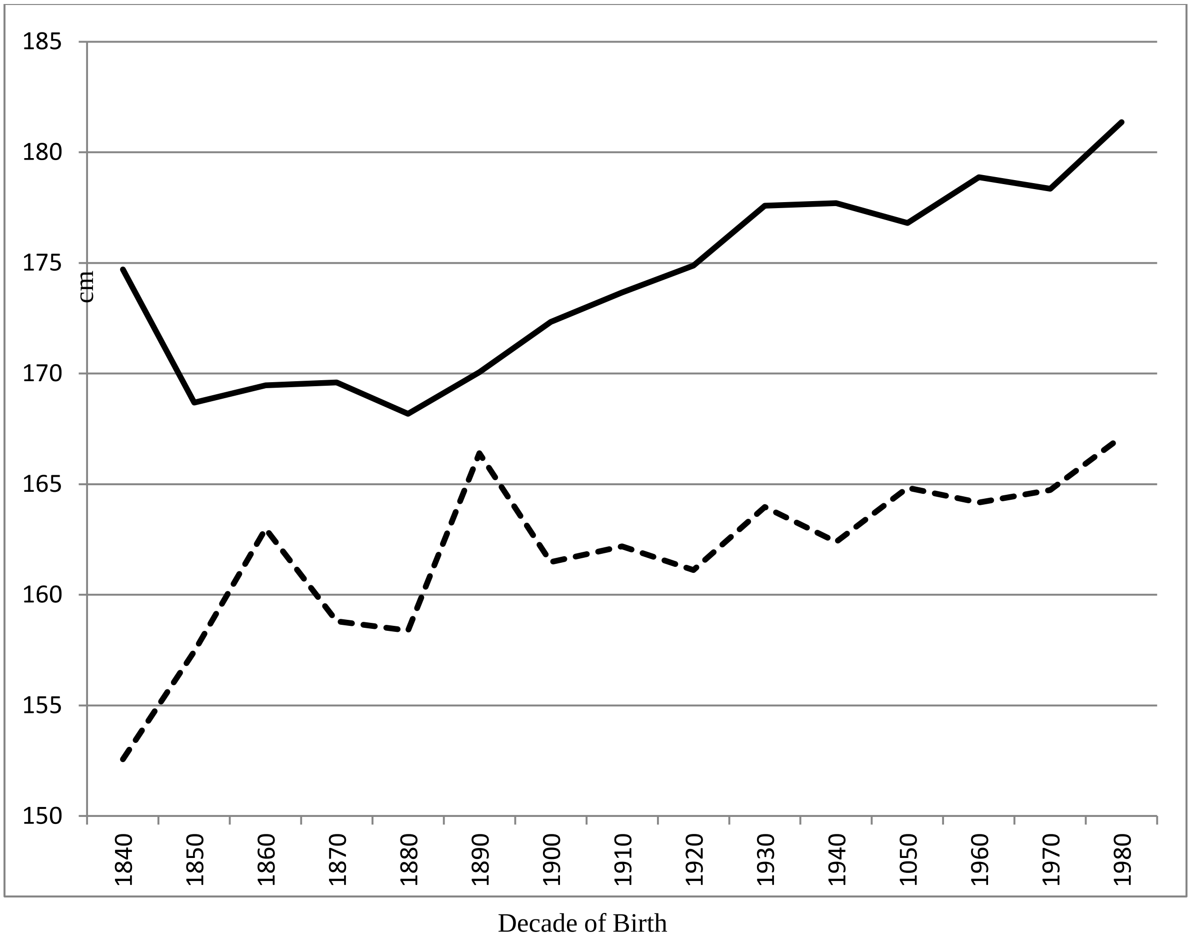
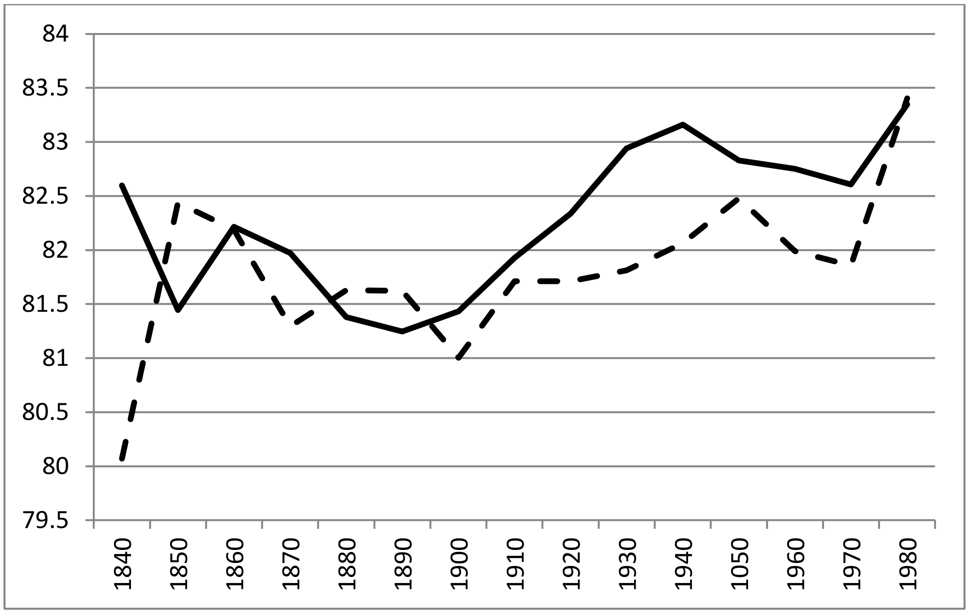
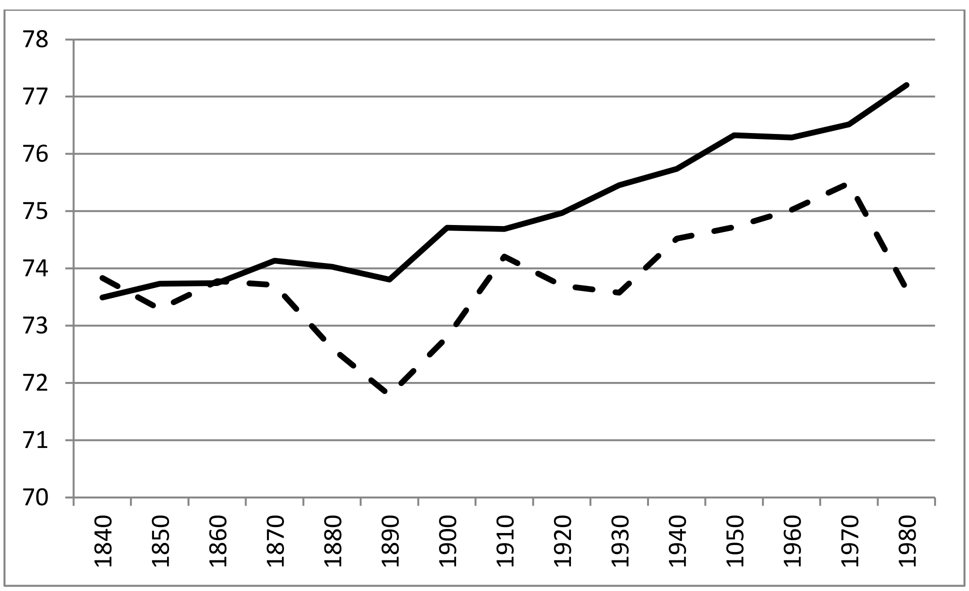


Figure 2. Stature by decade of birth. Males are solid lines, and females are dashed.



Decade of Birth

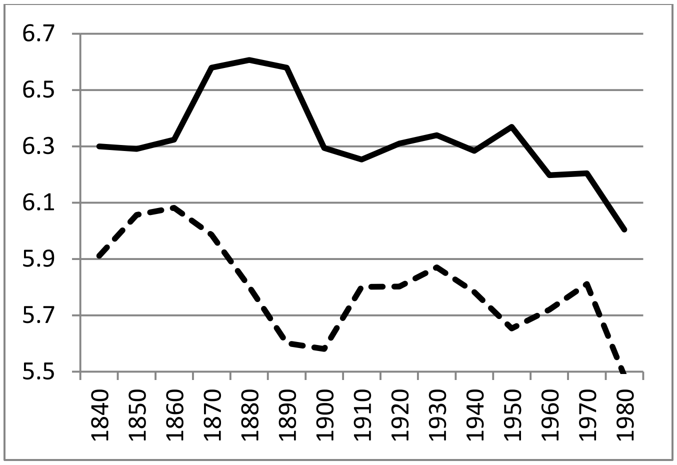
A. Crural index



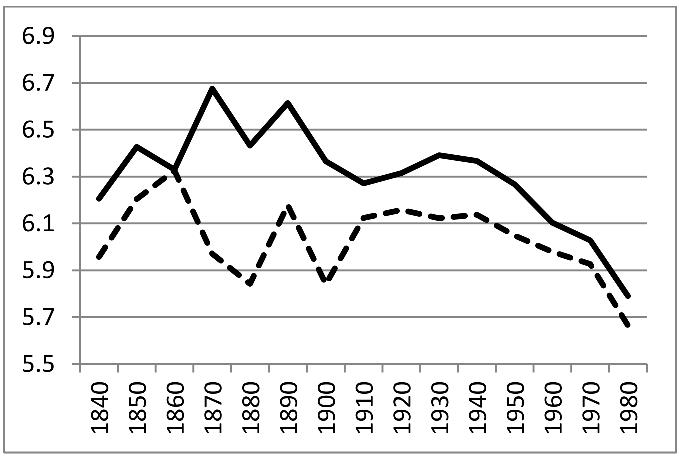
Decade of Birth

B. Brachial index.

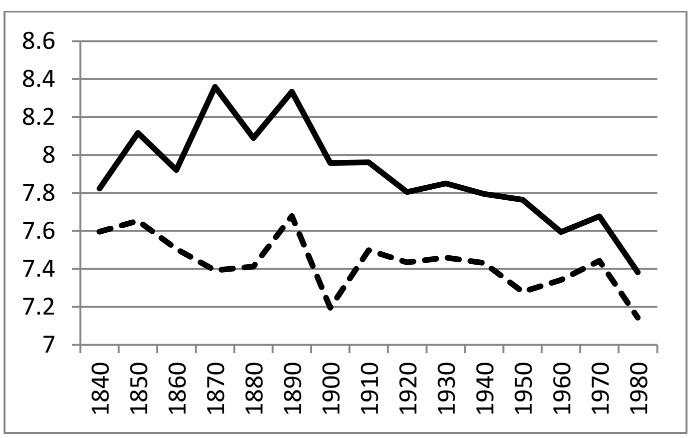
Figure 3. Crural (A) and brachial (B) indices by decade of birth. Males are solid lines, and females are dashed.



A. Humerus Robusticity

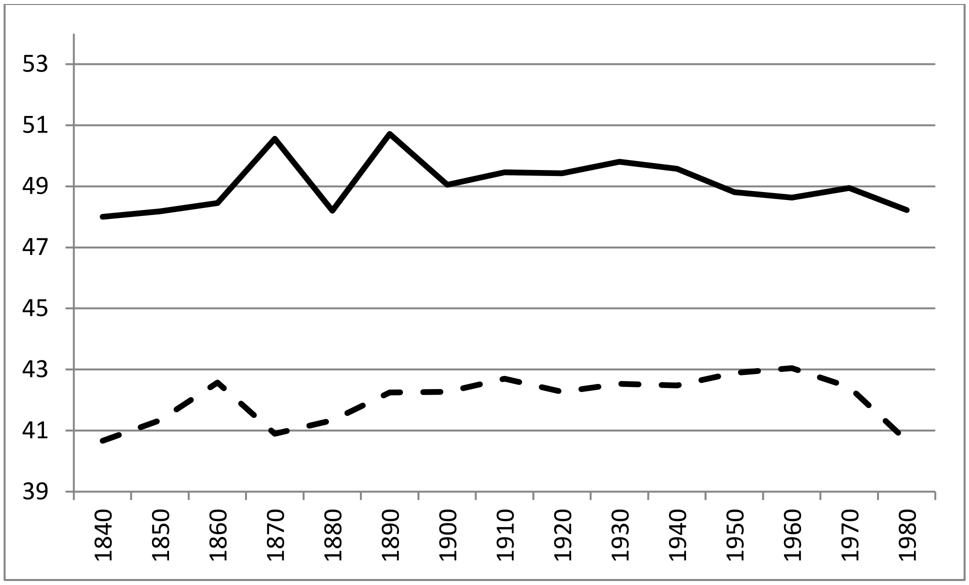


B. Femur Midshaft Robusticity

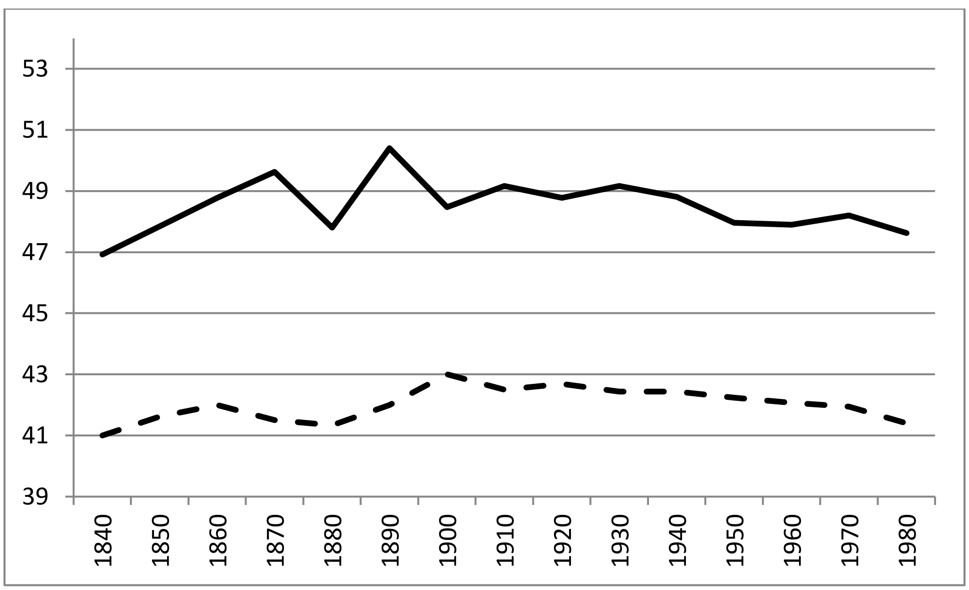


C. Tibia Nutrient Foramen Robusticity

Figure 4. Robusticity by decade of birth. Males are solid lines, and females are dashed.

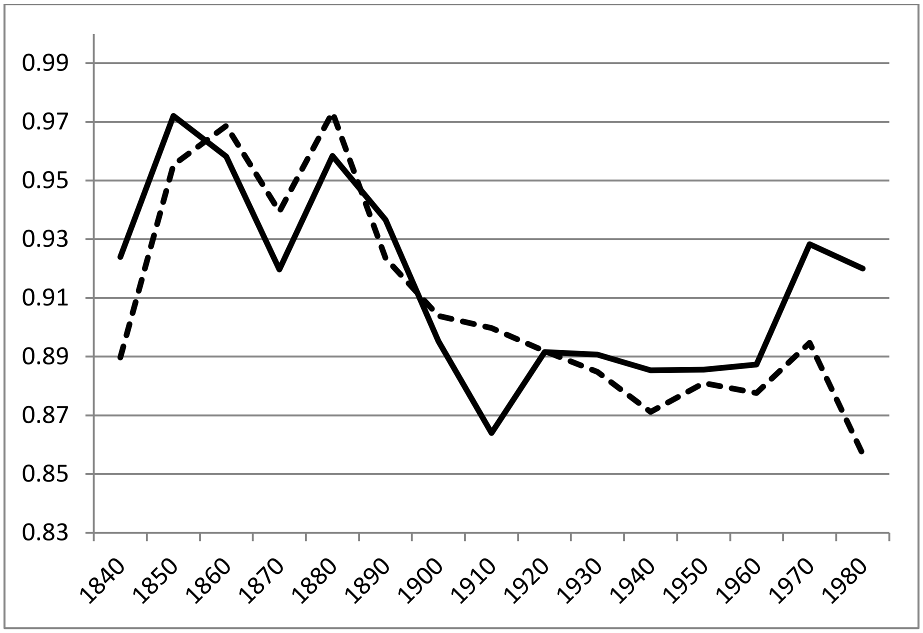


A. Humeral Head Diameter

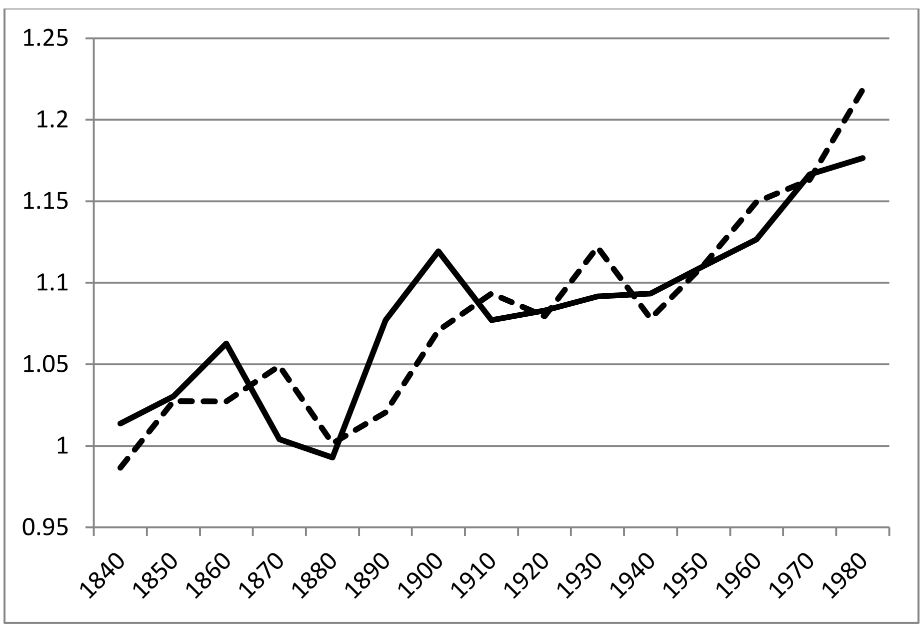


B. Femoral Head Diameter

Figure 5. Humeral (A) and femoral (B) head diameters by decade of birth. Males are solid lines, and females are dashed.



A. Platymeric index



B. Femur midshaft shape

Figure 6. Platymeric index (A) and femur midshaft shape by decade of birth. Males are solid lines, and females are dashed.

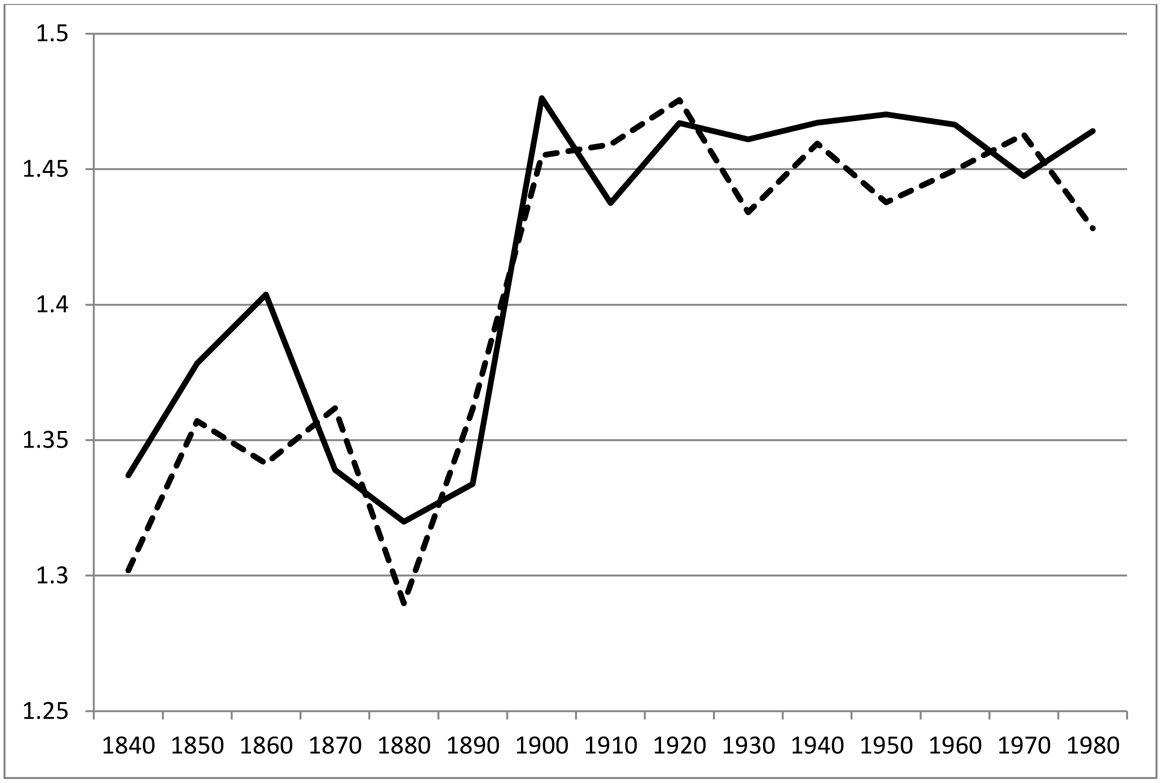


Figure 7. Cnemic index by decade of birth. Males are solid lines, and females are dashed.