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STATURE OF THE MEROVINGIAN-PERIOD INHABITANTS FROM LEVÄNLUHTA, FINLAND

Abstract
Statures of the Merovingian-period people buried in Levänluhta, Finland, are estimated by using equations calibrated for early medieval (AD 500–1000) Europeans. These new stature estimations (males 165.8 cm; females 153.4 cm) indicate that they were somewhat shorter than average for their period. This somewhat short stature may indicate impoverished living conditions and thus support a view that individuals buried in this marsh were slaves and/or poor. However, the possibility that these bones derive from human sacrifices or victims of an epidemic cannot be ruled out. In any event, due to phenotypic plasticity of stature, the Levänluhta people were not too short to be ancestors of the more recent inhabitants of Finland.

Keywords: Levänluhta, stature estimation, phenotypic plasticity

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INTRODUCTION

The early Merovingian-period (ca. AD 600–650) human bones recovered in 1886 from a marsh in Levänluhta (Ostrobothnia, Finland) have generated considerable interest in Finland for a long time (Pesonen 1939; Meinander 1950; Formisto 1993). This marsh may have been a sacrificial site or an execution site (Formisto 1993 with references), a burial site for slaves and poor (Meinander 1950), or victims of an epidemic (Seger 1982).

Earlier and more recent researchers have been particularly intrigued by very short stature – males 157.8 cm and females 146.9 cm (Pesonen 1939) – combined with low cranial indices of individuals buried at Levänluhta (Pesonen 1939; Formisto 1993). They were supposedly too short to be ancestors of the modern Nordic race and had too low cranial indices to be ancestors of the Saami (Meinander 1950). Of course, this traditional racial typology tells us very little about genetic relationships of past and present populations.

Genetic affinities of the Levänluhta people are not a concern here. Instead, I focus on their supposedly very short stature. I demonstrate that the Levänluhta people were not as short as they are commonly thought to have been, although they were somewhat shorter than average for their period; their relatively short stature may indicate their low social status; there is no reason to think that the Levänluhta people were too short to be ancestors of more recent inhabitants of Finland due to considerable phenotypic plasticity of stature.

MATERIALS AND METHODS

This research is based on numerical data provided by Formisto (1993) on the Levänluhta material supplemented by my own observations and measurements of this material at the National Board of Antiquities, Helsinki, Finland. My conclusions on the Levänluhta people's average stature differs from those of other researchers (e.g. Pesonen 1939; Formisto 1993) primarily due to differences in sex-assessment criteria.

My sex assessments of the Levänluhta specimens are based on European reference materials.

I compare long-bone lengths and estimated statures of the Levänluhta people with those of their contemporaries, as well as those of earlier and more recent Europeans. This comparative material is collected from the available literature.

I used data on three early medieval skeletal samples from Holliday (1995: Appendix 3). The Romano-British are from the Romano-British site of Poundbury Camp, Dorchester, England, and date to the middle of the fourth century. The Anglo-Saxon sample is composed of skeletons from 12 cemeteries in England dated between the Anglo-Saxon and Norman invasions (ca. AD 400–1066). The French sample is from the St. Etienne cemetery in Toulouse, Haut Garonne, France (Holliday 1995 with references).

A Late Roman Period skeletal population from a cemetery of Tác-Margittelep represents the early medieval Pannonians and dates to AD 380–430 (Éry 2000). The Roman Period (AD 1–400) Danish material is from Sellevold et al. (1984). I used the long-bone length data in Kemkes-Grottenhaler (2005) for the early medieval period (AD 500–1000) Europeans due to large numbers of individual skeletons and extensive geographical coverage as the reference data to generate equations to estimate statures of the early medieval Europeans.

Data on the Neolithic Europeans is from Formicola and Franceschi (1996), whereas that on the Neolithic Danes is from Bröste and Jørgensen (1956). Data on the 18th century Norwegian Saami is from Schreiner (1935).

Data on the 19th century French is the so-called Rollet's data. In this article, I used corrected means provided in Dupertuis and Hadden (1951: Table 8). Data on the early 20th century Finns is from Telkkä (1950).

Accurate estimation of stature of osteo-archaeological specimens is not as straightforward as commonly assumed. Regression equations (e.g. Telkkä 1950; Dupertuis & Hadden 1951; Trotter & Gleser 1952, 1958) developed for recent populations to estimate stature from long bone lengths often provide incorrect stature estimations for past populations (Formicola & Franceschi 1996) due to temporal changes in body proportions (Jantz & Jantz 1999). Based on the mean values provided by Kemkes-Grottenhaler (2005), the early medieval (AD 500–1000) Europeans had relatively longer distal limb segments (the radius, ulna, tibia and fibula) and shorter proximal limb segments (the humerus and femur), but probably not different total limb length-stature ratio than more recent Europeans of the same stature. Regression equations developed for recent Europeans (e.g. Telkkä 1950; Trotter & Gleser 1952, 1958) thus generally overestimate their statures from the proximal limb segments and underestimate them from distal limb segments.

Table 1. Reduced major axis equations to estimate statures of the early medieval Europeans.

Sex	Bone	Equation
Male	Humerus	[3.936 x (Hum-32.9)]+170.66
	Radius	[5.299 x (Rad-24.7)]+170.66
	Ulna	[5.177 x (Uln-26.5)]+170.66
	Femur	[2.804 x (Fem-45.5)]+170.66
	Tibia	[2.991 x (Tib-37.1)]+170.66
Female	Humerus	[3.936 x (Hum-30.3)]+158.23
	Radius	[5.299 x (Rad-22.7)]+158.23
	Ulna	[5.177 x (Uln-24.5)]+158.23
	Femur	[2.804 x (Fem-41.9)]+158.23
	Tibia	[2.991 x (Tib-34.4)]+158.23

Most regression equations are not entirely satisfactory even when applied to the populations they were originally developed for. As Sjøvold (1990) and Hens et al. (1998) have pointed out, least-squares regression equations (e.g., Trotter & Gleser 1952, 1958) generally underestimate statures of tall individuals and overestimate those of short individuals. This bias is particularly clear in the case of Telkkä's (1950) equations.

The ideal solution to this problem is to apply the anatomical method, which is based on the sum of all the skeletal components of stature to estimate statures of osteological specimens (Fully 1956; Formicola & Franceschi 1996; Maijanen & Niskanen 2006; Raxter et al. 2006). Unfortunately, this approach cannot be applied to the Levänluhta material, which is composed of isolated skeletal elements rather than complete skeletons.

Because none of the existing regression equations is appropriate for the early medieval Europeans, I generated reduced major axis (RMA) equations by using a method described by Sjøvold (1990). These RMA equations are easy to obtain from means (AV) and standard deviations (STD) of the dependent (Y) and the independent (X) variable. For example, when estimating stature from the femoral length, stature is the dependent variable (Y) and the femoral length is the independent variable (X). Stature is estimated by multiplying the ratio of the standard deviations of the dependent and independent variables (STD of the dependent variable is divided by STD of the independent variable) with the difference between the dependent variable and its mean value, and by adding the mean stature to the result. The equation is as follows:

$$Y = [(Y_{STD} / X_{STD}) \times (X-X_{AV})] + Y_{AV}$$

In the case of existing least squares equations, the reduced major axis slope can be derived from the ordinary least squares slope by dividing it by the correlation coefficient. The intercept can then be re-computed from the means of dependent and independent variables (Hens et al. 1998).

The mean statures of the early medieval Europeans are naturally not known and have to be estimated. I derived mean sex-specific values for maximum lengths of humerus, radius, femur and tibia for the early medieval (AD 500–1000) Europeans from Kemkes-Grottenthaler (2005: Table 3). I estimated the maximum length of the ulna from the radial maximum length by a simple addition of 1.8 cm (the mean length difference of radius and ulna in both sexes) to the radial length because the length difference between these two long bones have practically zero correlations with the absolute bone lengths (Niskanen, personal observation).

There is no reason to assume that the ratio of the standard deviation (STD) of stature and those of long bone lengths (STD of stature/STD of a bone length) differ between the early medieval people and the more recent Europeans and people of European descent. Therefore, I computed these ratios by using standard deviations of white soldiers, 21 years and older, who died in the Korean War (Trotter & Gleser 1958: Table 8). These ratios are as follows: humerus 3.936, radius 5.299, ulna 5.177, femur 2.804 and tibia 2.991.

I have assumed that the total limb length-stature ratios of the early medieval Europeans were similar to those of recent Europeans of the same stature regardless of differences in the distal-proximal limb segment ratios. This is a safe assumption because there has been only stature-related fluctuation in the total limb length-vertebral column length ratio in Europe since the Last Glacial Maximum about 20,000 years ago (Niskanen & Junno 2006; Niskanen, unpublished data). For this reason, I used mean values for stature, femoral length and tibial length of the white Korean War casualties from Trotter and Gleser (1958) and recent white American females from Jantz (1992) to estimate mean statures of the early medieval Europeans from their femoral and tibial lengths.

I estimated stature from the femoral length with the following equations:

Male stature = 175.11-[2.804 x (47.18-45.5)]
Female stature = 163.0-[2.804 x (43.832-41.9)]

I estimated stature from the tibial length with the following equations:

Male stature = 175.11-[2.991 x (38.5-37.1)]
Female stature = 163.0-[2.991 x (35.781)]

Means of estimates based on the femoral and tibial lengths are mean statures of the early medieval Europeans. This calculation provided mean statures of 170.66 cm (the mean of 170.40 and 170.92) for males and 158.23 cm (the mean of 157.58 and 158.87) for females. These values were then used as intercepts in equations to estimate stature from long-bone lengths (Table 1).

These equations could be tested on the early medieval Europeans only if there are a large enough number of complete early medieval skeletons for the application of the recently revised anatomical method to estimate living statures of skeletal specimens (Maijanen & Niskanen 2006; Raxter et al. 2006). Although these equations are untested, I am confident that they provide more accurate stature estimations for the early medieval European skeletal samples, including the Levänluhta specimens, than commonly applied regression equations (e.g. Telkkä 1950; Trotter & Gleser 1952, 1958) because directional bias to estimate statures of tall or short individuals has been eliminated and because relatively longer distal limb segments and shorter proximal limb segments of the early medieval Europeans are taken into account.

Accurate sex assessment of osteological specimens matters because most of the stature-estimation equations are both sex- and population-specific. This sex assessment of adults from the pelvic morphology is quite accurate. Relative proportions of the acetabulum (the hip socket), pubic bone and the ischium alone allow correct sex assessment for at least 95 % of individuals. Sex determination from the skull has an accuracy rate of ca. 85 %. Joint surface areas (e.g. the femoral head diamater) allow correct sex assessment of ca. 90 % of individuals (Krogman & Iscan 1986).

Because it is not possible to match skulls and limb bones with the pelvic bones from Levänluhta with a reasonable accuracy, sex determination has to be performed separately for each bone based on its dimensions. Due to her prior assumption that the Levänluhta individuals were very short, Formisto (1993) applied Hanikara's (1958) discriminant functions based on the Japanese reference population on the humerus, ulna, femur and tibia to determine sex of the Levänluhta specimens. I consider Hanikara's (1958) discriminant functions inappropriate for the European skeletal samples because they tend to misclassify many average-sized European females as males. This misclassification is primarily due to the larger average articular (joint) sizes of the Europeans' long bones (e.g. the femoral head diameter). As will be pointed out later, the hip socket sizes of the Levänluhta specimens indicate that they had typically European joint sizes.

There are two reasons why we can expect that the Levänluhta and other Iron Age inhabitants of Fennoscandia did not deviate significantly from earlier and more recent Europeans in respect to their joint sizes. First, the joint sizes exhibit considerably less between-population variation than long bone lengths in Europe. For example, although the medieval Norse males have much longer femora than the 18th century Norwegian Saami males (the physiological femoral lengths are 461.0 mm and 410.4 mm, respectively), their femoral head superior-inferior diameters are only two millimeters larger (48.3 mm vs. 46.3 mm, Schreiner 1935). Second, there is considerably less temporal variation in the joint sizes than in the long bone lengths in Europe. For example, the femoral head diameter has fluctuated remarkably little since Early Upper Paleolithic (ca. 35–10 ky bp) although there have been considerable temporal fluctuation in long bone lengths and

Table 2. Acetabular heights (ACHT) of those hipbones from Levänluhta the sex of which is determined.

Specimen number	Side	Sex	ACHT	FHSI (predicted)
33	L	M	55.0	46.8
7a	L	F	47.0	40.0
20	L	F	48.5	41.3
16	L	F	49.0	41.7
18	L	F	46.5	39.5
21	L	F	49.3	41.9
34	L	F	53.0	45.1
24	L	F	49.0	41.7
23	L	F	53.0	45.1
22	L	F	49.0	41.7
35	L	F	47.5	40.4
?	L	F	51.0	43.4
?	L	F	48.0	40.8
7b	R	F	49.0	41.7
12	R	F	47.5	40.4
30	R	F	52.5	44.7
25	R	F	43.0	36.5
27	R	F	48.0	40.8
26	R	F	49.5	42.1
32	R	F	49.5	42.1
237?	R	F	55.0	46.8
?	R	F	51.5	44.1
?	R	F	48.0	40.8

Side: L = left side, R = right side; Sex: F = female, M = male. FHSI (the femoral head superio-inferior diameter) is estimated from ACHT by a regression equation (FHSI = 0.86 x ACHT-0.458, r = 0.93, Rosenberg 1988).

presumably average stature (Holliday 1995; Niskanen & Junno 2006).

The past and present Europeans have larger joint areas than Africans and Asians because Europeans are genetically programmed to be able to reach much larger average body size. This is especially clear when comparing Europeans and Sub-Saharan Africans (Holliday 1995, 1997; Ruff 2002). Even the diminutive Norwegian Saami of the 18th century have bigger average femoral head diameters than the South African Zulu (midsex means 43.9 mm vs. 43.1 mm, Schreiner 1935; Grine et al. 1995), although the Zulu being quite large-bodied for the Sub-Saharan Africans (Eveleth & Tanner 1976) were definitely much taller and heavier than the Saami. It simply appears that joint sizes are not much affected by the overall growth, which in turn is affected by the overall nutrition and health. In contrast, the growth of long bones, and thus stature, are quite sensitive to the overall nutrition and health and, therefore, exhibits considerable phenotypic plasticity.

Table 3. Acetabular heights (ACHT) and both observed (FHSI observed) and predicted femoral head heights (FHSI predicted).

	Sex	ACHT	FHSI (observed)	FHSI (predicted)	Reference
Spec. #33 (L)	M	55.0	--	46.8	This work
Left innom. N = 12	F	49.2 + 2.1 (46.5-53.0)	40.8 + 2.0 (38.0-44.5) N = 9	41.9 + 1.7 (39.5-45.1)	Formisto (1993); This work
Right innom. N = 10	F	49.4 + 3.2 (43.0-55.0)	39.3 + 1.5 (37.0-41.1) N = 6	42.0 + 2.7 (36.5-46.8)	Formisto (1993); This work
Europe	M	56.5 (89)	48.1 (86)	--	Holliday (1995)
Medieval Norse	M	--	48.3	--	Schreiner (1935)
Saami	M	--	46.3 (233)	--	Schreiner (1935)
North Africa	M	53.7 (34)	44.8 (34)	--	Holliday (1995)
West Africa	M	52.5 (16)	43.5 (16)	--	Holliday (1995)
East Africa	M	50.3 (27)	43.3 (27)	--	Holliday (1995)
Zulu	M	--	45.5 (25)	--	Grine et al. (1995)
Europe	F	50.2 (63)	41.7 (64)	--	Holliday (1995)
Medieval Norse	F	--	42.6	--	Schreiner (1935)
Saami	F	--	41.5 (175)	--	Schreiner (1935)
North Africa	F	47.8 (32)	39.5 (35)	--	Holliday (1995)
West Africa	F	48.9 (4)	40.0 (5)	--	Holliday (1995)
East Africa	F	46.9 (19)	38.8 (19)	--	Holliday (1995)
Zulu	F	--	40.6 (25)	--	Grine et al. (1995)

Sex: F = female, M = male. FHSI is predicted with a regression equation (FHSI = 0.86 x ACHT-0.458, r = 0.93, Rosenberg 1988). Observed and predicted femoral head diameters of the Levänluhta specimens are not matched, which at least partly explains differences in mean values.

Our joint areas are reliable indicators of sex because they exhibit more sexual dimorphism than other skeletal dimensions, apart from the clavicular length. There is simply less overlap in the femoral head size, for example, than in the long-bone lengths between males and females. About 11 % of women have femora as long or longer than the average male femur of their population, but only about 0.5 % have as large or larger femoral head diameters (computed from Krogman & Iscan 1986: Table 7.10). For the above reasons, if the pelvis is not available, the sex determination of osteological specimens should be based on the joint sizes rather than long bone lengths.

I first demonstrate that the acatabular (hip socket) sizes indicate that the Levänluhta people had typically European joint sizes and thus their sex determinations from long-bone dimensions should be based on the European reference data instead of Japanese reference data. After that, I compare long bone-lengths and estimated statures of the Levänluhta people with those of earlier and later Europeans.

RESULTS

The acetabular height (M-22; this and other number codes used in this article refer to measurements defined in Martin 1928) was possible to measure from a total of 13 left innominate and 10 right innominate from Levänluhta. All but one of these hip bones exhibit female morphology (Table 2).

The mean acetabular height of definite or very likely females from Levänluhta is 49.3 mm (12 from the left side averaged 49.2 mm; 10 from the right side averaged 49.4 mm). The acetabular height of the only male from Levänluhta (a left innominate #33) is 55 mm. Because the acetabular height has a high correlation (r = 0.93, Rosenberg 1988) with the femoral head size, which is often used in sex determination, I estimated the femoral head superior-inferior diameter (FHSI) from the acetabular height (ACHT) by a regression equation (FHSI = 0.86 x ACHT-0.458, r = 0.93, Rosenberg 1988). The estimated acetabular height of the only definite male from Levänluhta is 46.8 mm, whereas the mean femoral head diameter of females is about 41.9–42.0

Table 4. Sex-determination differences between Formisto (1993) and Niskanen (this article).

Specimen	Formisto	Niskanen
Humerus 4L	Male	Female
Humerus 28L	Male	Female
Humerus 29L	Male	Female
Humerus 36L	Male	Female
Humerus 10R	Male	Female
Humerus 11R	Male	Female
Humerus 16R	Male	Female
Radius 1L	Male	Female
Radius 7L	Male	Female
Radius 18L	Male	Female
Radius 29R	Male	Female
Ulna 20R	Female	Male
Femur 2L	Male	Female
Tibia 4L	Female	Male

Number refers to specimen numbers in Formisto's (1993) tables and capital letter to the side (L = left, R = right).

mm. Observed acetabular heights and estimated femoral head diameters of the Levänluhta individuals are quite typical for the Europeans (Table 3). For this reason, I have based their sex determinations on the European reference data.

The application of a discriminant function to distinguishing the sex of American whites on the basis of humeral epicondylar breadth (M-4), maximum head diameter (M-9) and minimum midshaft diameter (M-6) indicates that there is only one male humerus (No. 9 right side) in the Levänluhta sample (Bennett 1993: Table 19). The application of a discriminant function based on a mixed sample of American whites, blacks and Hispanics (Bennett 1993: Table 21) did not change this sex determination.

The application of a discriminant function to distinguishing the sex of American whites, blacks and Hispanics on the basis of radial anterior-posterior midshaft diameter (M-5) and transverse midshaft diameter (M-4; stated accuracy 86 % for males, 99 % for females; Bennett 1993: Table 21) identified only two males (No. 17L and 27R).

I applied a discriminant function of Holman and Bennett (1991) to distinguish the sex of American whites on the basis of the length of ulna (M-1) and the maximum distal breadth, which the above authors measured from the most lateral point on the head to the most lateral point of the styloid process of ulna. At first I had to convert sagittal diameters of the caput (M-11a) provided by Formisto (1993: Tables 11.1 & 11.2) to the maximum distal breadth used by Holman and Bennett (1991) by multiplying the sagittal diameter of the caput by 1.2 (the ratio between these two diameters). This discriminant function classified all of the specimens originally classified as males by Formisto (1993) as males, as also one specimen originally classified as female (No. 20R). I am not very satisfied with my sex determination of the Levänluhta ulna for two reasons. First, the estimation of dimensions always includes some estimation error. Second, the length of ulna is included in the discriminant function, which undermines my desire to not include bone lengths in sex assessment.

I applied a discriminant function to assess the sex of American whites on the basis of the femoral head diameter (M-18) and transverse diameter of midshaft (M-7; Krogman & Iscan 1986: Table 6.24). All femora from Levänluhta belonged to females according to this analysis. However, one specimen (No. 2L) received a discriminant func-

Table 5. Mean long-bone lengths of the Levänluhta people according to sex and side.

	Side	Males	Females
Humerus (M1)	Left	--	289.0 (12)
		--	± 12.2
		--	271-306
	Right	308.0 (1)	285.6 (11)
		--	± 14.2
		--	257-304
Radius (M1)	Left	229.0 (1)	220.5 (21)
		--	± 11.3
		--	190-242
	Right	241.0 (1)	217.2 (13)
		--	± 13.0
		--	193-239
Ulna (M1)	Left	259.3 (4)	236.2 (13)
		±6.2	± 13.6
		253-266	208-253
	Right	256.5 (2)	242.2 (9)
		--	± 11.4
		251 & 262	226-257
Femur (M1)	Left	--	400.1 (7)
		--	± 29.5
		--	363-448
	Right	--	367.5 (2)
		--	--
		--	354 & 381
Tibia (M1)	Left	356.5 (2)	333.3 (9)
		--	± 19.4
		343 & 370	305-367
	Right	346.0 (1)	318.4 (7)
		--	± 18.3
		--	288-337

tion score of -0.66, which is not much below the sectioning point of zero. Formisto (1993: 98) had classified this specimen as male on the basis of its maximum femoral head diameter (44.5 mm). I consider this specimen more likely female than male for three reasons. First, its discriminant score (-0.66) indicates female. Second, its femoral head diameter is below the sectioning point (45 mm) used by Krogman and Iscan (1986: Table 6.24). Third, based on the femoral head diameters estimated from the acetabular heights the Levänluhta sample (see Table 2) includes two or three females (34L, 23L and 237R) that had femoral head diameters of at least 45 mm.

I used two different discriminant functions to assess the sex of American whites on the basis of tibial dimensions: from the proximal (M-3) and distal epiphyseal breadths (M-6); from the distal epiphyseal breadth (M-6) and minimum shaft circumference (M-10b; Krogman & Iscan 1986: Table 6.26). This procedure identified three males. Two of these Formisto (1993) had originally identified as males (No. 9L and 23R), but one of these she had identified as female (No. 4L). This specimen received a borderline discriminant score (0.22) based on a combination of its distal epiphyseal breadth and minimum shaft circumference due to its rather small minimum shaft circumference (64 mm), but its distal epiphyseal breadth (49 mm) justifies its classification as male.

Cases where my sex determinations are different from those of Formisto are listed in Table 4. In 12 cases I have changed Formisto's (1993) sex determination from male to female, but in two cases (one ulna and one tibia) I have changed sex determination from male to female.

Because my sex assessments are different from those of Formisto (1993), I have recomputed mean long bone lengths for the Levänluhta specimens by sex. Due to classifying so many specimens originally classifies as males as females, my mean values provided in Table 5 differ somewhat from those provided by Formisto (1993).

The long bones from Levänluhta are not exceptionally short. They are actually longer than those of the Norwegian Saami and not much shorter than those of the Neolithic period Europeans, the Middle Neolithic Danes and the 19th century French. The Levänluhta males have somewhat shorter long bones than those of the early medieval period Europeans and the early 20th century Finns (Table 6a), whereas the Levänluhta females have long-bone lengths more in line with these reference samples (Table 6b).

I applied stature estimation equations provided in Table 1 to estimate statures from the long bone lengths. In case of the Levänluhta specimens, I computed mean statures for males and females by using both my own and Formisto's (1993) sex determinations. The stature estimations based on different long bones provided in Table 7 demonstrate that differences in sex determination combined with small sample sizes affect the mean stature of the Levänluhta males a great deal. Sex determination differences do not affect the mean stature of females due to much bigger sample sizes for females. The mean stature based on all of the long bones, left and right side combined, for males is 165.8 cm (N=12) and for females 153.4 cm (N=104).

The stature estimations based on the most numerous long bone, and thus the minimum number of individuals, are somewhat higher (see Table 5 for the mean long-bone lengths). The left ulna is the most numerous long bone in case of males and the left radius in case of females. The mean stature of males based on four left ulnae is 167.7 cm (range 164–171.2 cm). The mean stature of females based on 21 left radii is 154.8 cm (range 138.6–166.2 cm). It is entirely possible that the sample of complete long bones from Levänluhta originates from only four males and 21 females.

I compared male and female mean statures of the Levänluhta specimens with those of their contemporaries. The mean statures of the Levänluhta people are mean statures based on all of the long bones. The mean statures of other Iron Age and early medieval samples are means of estimations based on the humeral, radial, femoral and tibial lengths because I did not have the length of ulna for all of these comparative samples. Stature estimations based on lower limb bones only would have provided more accurate stature estimations than those based on both upper and lower limb bones, but I wanted to make stature estimations more directly comparable with those of the Levänluhta specimens.

Comparisons with other osteological samples indicate that the Levänluhta people were quite short but not exceptionally short. Their mean stature was quite similar to that of the Late Upper

Table 6a. Mean long-bone lengths of the Levänluhta males compared with those of early medieval European, Neolithic Europeans, the 19th century French, the early 20th century Finns and the 18th century Norwegian Saami.

Sample	Humerus (M1)	Radius (M1)	Ulna (M1)	Femur (M1)	Tibia (M1)
Levänluhta	308.0 (1)	235.2 (2)	258.3 (6)	--	353.0 (3)
Romano-British	329.7 (25)	248.5 (25)	--	456.2 (25)	362.6 (25)
Anglo-Saxon	332.6 (165)	251.0 (113)	--	461.3 (167)	370.9 (159)
Early Medieval French	311.9 (11)	237.3 (11)	--	438.5 (12)	360.0 (13)
Roman Period Danes	340.1 (43)	260.9 (33)	279.6 (27)	475.4 (59)	382.5 (38)
Late Roman Period Pannonians	319.2 (79)	243.1 (76)	264 (72)	448.3 (73)	362.4 (75)
Early Medieval Period	329 (1175)	247 (1175)	265.0 (1175)	455 (1175)	371 (1175)
Neolithic Period Europe	310.3 (33)	241.3 (33)	--	437.4 (33)	359.0 (33)
Middle Neolithic Danes	323.0 (14)	242.0 (4)	275.7 (3)	436.0 (23)	362.3 (15)
Late Neolithic Danes	342.6 (55)	267.0 (31)	293.1 (27)	479.1 (61)	398.0 (60)
19th century French	326.0 (24)	243.9 (24)	--	445.2 (24)	363.4 (24)
Early 20th century Finns	328.9 (115)	243.4 (115)	--	454.8 (115)	361.6 (115)
Norwegian Saami	306.7 (298)	227.1 (238)	246.1 (197)	412.8 (303)	324.2 (296)

Table 6b. Mean long bone lengths of the Levänluhta females compared with those of early medieval Europeans, Neolithic Europeans, the 19th century French, the early 20th century Finns and the 18th century Norwegian Saami.

Sample	Humerus (M1)	Radius (M1)	Ulna (M1)	Femur (M1)	Tibia (M1)
Levänluhta	287.4 (23)	219.2 (34)	238.6 (22)	398.9 (9)	326.8 (16)
Romano-British	292.9 (27)	218.7 (27)	--	417.9 (27)	332.0 (27)
Anglo-Saxon	309.9 (69)	227.1 (53)	--	427.1 (66)	344.8 (65)
Early Medieval French	293.1 (10)	216.7 (11)	--	403.3 (9)	329.4 (10)
Roman Period Danes	308.9 (31)	233.4 (26)	251.3 (20)	435.0 (38)	355.5 (30)
Late Roman Period Pannonians	291.4 (91)	216.4 (81)	236.7 (72)	410.2 (99)	332.2 (97)
Early Medieval Period	303 (942)	227 (942)	245.0 (942)	419 (942)	344 (942)
Neolithic Period Europe	282.6 (27)	214.8 (27)	--	400.6 (27)	325.1 (27)
Middle Neolithic Danes	287.9 (11)	225.5 (11)	257.3 (7)	401.1 (10)	327.1 (10)
Late Neolithic Danes	318.9 (27)	248.8 (17)	269.0 (15)	439.5 (17)	363.8 (15)
19th century French	293.6 (25)	212.7 (25)	--	408.6 (25)	329.7 (25)
Early 20th century Finns	307.2 (39)	222.4 (39)	--	417.7 (39)	331.2 (39)
Norwegian Saami	283.5 (163)	207.7 (194)	224.9 (172)	384.2 (262)	299.9 (249)

Paleolithic, Mesolithic and a combined sample of Neolithic period Europeans. They were much shorter than the early Upper Paleolithic period Europeans and the late Neolithic Danes, somewhat shorter than most late Iron Age and early medieval period Europeans, but about the same height as the early medieval French and the late Roman period Pannonians (Table 8).

Comparisons with anthropometric samples do not indicate that the Levänluhta people were exceptionally short. Although they were much shorter than the late 20th century Finns they were taller than the early 20th century Finnish Saami. They were actually about the same height as the early 20th century inhabitants of eastern and northern Finland (Savo, Karelia and North-Ostrobothnia), as well as the Finnish Saami measured in the 1970s (Table 8).

DISCUSSION

The following examples demonstrate that there is a great deal of phenotypic plasticity in stature. The somewhat short average stature of the

Table 7. Effect of differences of sex determination on mean statures.

	Males		Females	
	Formisto (1993)	This work	Formisto (1993)	This work
Humerus	157.3 (8)	162.4 (1)	150.1 (16)	152.1 (23)
Radius	160.4 (6)	161.1 (2)	153.5 (30)	154.1 (34)
Ulna	168.0 (5)	163.4 (6)	155.3 (23)	154.9 (22)
Femur	159.4 (1)	--	149.9 (8)	150.9 (9)
Tibia	166.8 (2)	165.3 (3)	153.6 (17)	153.1 (16)
Total	161.5 (22)	165.8 (12)	153.1 (94)	153.4 (104)

Levänluhta people is, therefore, not a valid reason to exclude them as among the ancestors of more recent inhabitants of Finland. However, it may indicate that these bones derive from individuals that had grown up in relatively impoverished conditions.

Stature can increase considerably across generations. The mean stature of Finnish males (ages 20–21) starting their military service in 1921 and 1922 was 169.0 cm. A year later, at the end of the military service, the mean was 170.3 cm indicating that most males were still growing in stature (Kajava 1926). Therefore, the mean stature (171.01 cm) of fully adult men in the prime age group (25–45 years) provided by Wilksman (1922, referenced in Kajava 1926) is probably close to the actual final stature of the Finnish men born in the late 19th century and early 20th century. The mean stature of conscripts had increased to 177.4 cm in 1977 (Dahlström 1981) and to 180.0 cm in 1997 (Aalberg & Siimes 1999). Stature of Finnish males has thus increased ca. 9 cm (from 171.01 cm to 180.0 cm) in three generations (75 years). This rate of increase would have made the Levänluhta males as tall as the Crusader period males from Tuukkala, Finland (Lehtosalo-Hilander 1988: 217) and young (ages 20–29) Finnish men measured between 1966 and 1972 (Heliövaara & Aromaa 1980) within three generations.

Stature increase was particularly fast between age cohorts born in the mid-20th century. The mean stature of 19-year-old inductees from North Karelia born in 1938 was 172.3 cm, whereas that of those born in 1958 was 176.8 cm. The mean stature of inductees born in Varsinais-Suomi, representing the same age cohorts, increased from 174.4 cm to 178.6 cm. Therefore, the mean stature of inductees increased over 4 cm (4.5 cm in North Karelia and 4.2 cm in Varsinais-Suomi) in 20 years in both regions of Finland (Dahlström 1981: Tables 5–16). This rate of increase (4.5 cm/ 20 years = 0.225 cm per year) would have made the Levänluhta people over 5 cm taller in just one generation (25 years).

There is less information of female stature in Finland. According to Pesonen (in Telkkä 1950), the mean statures of Finnish men and women (all ages) measured between 1924 and 1934 were 169.2 cm and 157.9 cm, respectively, during the first half of the 20th century. Young Finnish men and women (ages 20-29) measured between 1966 and 1972 averaged 175.3 cm and 161.9 cm, respectively (Heliövaara & Aromaa 1980). Current mean stature of young men is 180.0 cm (Aalberg & Siimes 1999) and young women ca. 166.2 cm (assuming female stature is 92.36 % of male stature as it was in Heliävaara and Aromaa 1980). The male stature has thus increased 10.8 cm and female stature 8.3 cm. A greater increase of male stature than female stature is expected because the growth of male children is more sensitive to disturbances (malnutrition and undernutrition) than that of female children (Eveleth & Tanner 1990). Stature increases of this magnitude would have made the Levänluhta males 176.6 cm tall and females 161.7 cm tall within a century.

Differences in the mean stature between individuals representing the same population that have grown in very different environments are even more considerable than temporal changes in the mean national stature. The mean statures of 18-year-old males from Kingston and rural parts of Jamaica were 174.5 cm and 164.5 cm, respectively, in the early 1960s (Eveleth & Tanner 1976: Appendix Table 40). Maya-American children are 10.24 cm taller than Maya of the same age living in Guatemala. 7.02 cm of this stature difference is due to differences in the lower limb length (Bogin & Rios 2003), which is almost entirely

Table 8. Statures compared.

	Stature (males)	Stature (females)	References
Iron Age and Medieval Europe			
Levänluhta	165.8 (12)	153.4 (104)	This work
	± 3.5	± 6.3	
	161.1-171.2	138.6-166.4	
Tuukkala	175	157	Lehtosalo-Hilander (1988)
Romano-British	169.6	156.3	Holliday (1995)
Anglo-Saxon	171.5	159.5	Holliday (1995)
Early Medieval French	166.7	153.8	Holliday (1995)
Roman Period Danes	175.2	162.2	Sellevold et al. (1984)
Late Roman Period Pannonia	168.4	155.2	Éry (2000)
Early Medieval Period	170.7	158.2	Kemkes-Grottenthaler (2005)
Stone Age Europe			
Early Upper Paleolithic	174.5	162.3	Niskanen & Junno (2006)
Late Upper Paleolithic	166.6	157.0	Niskanen & Junno (2006)
Mesolithic	169.6	157.0	Formicola & Giannecchini (1999)
Neolithic	165.7	152.3	Formicola & Franceschini (1996)
Middle Neolithic Danes	166.0	152.7	Bröste & Jørgensen (1956)
Late Neolithic Danes	177.4	163.5	Bröste & Jørgensen (1956)
Early 20th century Finland			
Åland	174.23	161.79	Arho (1934)
Varsinais-Suomi	171.68	159.99	Arho (1934)
Uusimaa (Swedish)	172.14	160.08	Löfgren (1937)
Uusimaa (Finnish)	169.65	159.33	Löfgren (1937)
Satakunta	170.79	159.14	Pesonen (1935)
South-Ostrobothnia (Swedish)	171.19	159.03	Mustakallio & Telkkä (1951)
South-Ostrobothnia (Finnish)	170.60	158.24	Mustakallio & Telkkä (1951)
Häme	170.55	158.08	Telkkä (1952)
Savo	167.44	154.53	Pesonen (1937)
Karjala	166.29	154.83	Roschier (1931)
North-Ostrobothnia	167.62	156.40	Kivalo (1957)
Saami	160.4	149.1	Näätänen (1936)
Late 20th century Finland			
Saami (ages 20–29) in the 1970s	167.0	154.7	Auger et al. (1980)
Finns (ages 20–29) 1966–1972	175.3	161.9	Heliövaara & Aromaa (1980)
Finns in the 1990s	180.0	(166.2)	Aalberg & Siimes (1999)

Statures of Levänluhta and other Iron Age and Medieval osteological samples are computed from long bones of both upper and lower limb, but those for the Tuukkala sample are skeletal lengths. Statures for Upper Paleolithic and Mesolithic Europeans are computed by correcting for estimation errors according to Maijanen and Niskanen (2006). Statures of the Neolithic Period Europeans are anatomical statures recomputed from date provided in Formicola and Franceschini (1996) according to Raxter et al. (2006). Statures of Neolithic Danes are computed from the femoral and tibial length by equations provided by Table 2.

due to combined femoral and tibial lengths each of which contributing 3–4 cm. An increase of similar magnitude of the Levänluhta people’s long-bone lengths and statures in just one generation (25 years) would have made their long bones as long and statures as tall as those of their tallest contemporaries.

No weapons had been found at Levänluhta (Formisto 1993: 186), implying that few if any free males, or males representing the upper class, were buried at this site. This lack of weapons may partly explain these males’ somewhat short stature. There are archaeological examples of Iron Age and early medieval populations, which indicate that males buried without weapons are generally shorter than males buried without weapons. For example, Alemann males from Weingarten buried without weapons were 3.6 cm shorter than those buried with many weapons (171.9 cm vs. 175.5 cm) based on Trotter and Gleser’s (1958) equations to estimate statures from long-bone lengths (Huber 1968: Table 1). The true stature difference was probably somewhat greater (ca. 4 cm rather than 3.6 cm) since Trotter and Gleser's (1958) equations underestimate statures of tall individuals and overestimate those of short individuals. Adding four centimeters to the male stature would make the Levänluhta males 169.8 cm tall and thus average for early medieval period.

There are differences in mean stature between different socioeconomic classes even today. For example, a survey of average statures performed in 1980 in Great Britain revealed that representatives of the highest social class were about three centimeters taller (males 3.2 cm; females 2.9 cm) than those of the lowest social class (Rosenbaum et al. 1985). It is quite possible that poor people and slaves of the Merovingian-period Finland suffered from inadequate diet at least as much as the British working class in the second half of the 20th century.

Because differences in stature reflect differences in the average nutritional status, the somewhat short long bones and thus low statures of the Levänluhta people may simply indicate their relatively impoverished living conditions and thus low social class. They may have been poor or slaves buried in marshes, whereas the representatives of the better-nourished local upper class (free individuals) were buried in cairns as Meinander (1950) has proposed.

CONCLUDING STATEMENS

The Levänluhta people were rather short but not exceptionally so for their period. It is quite possible that their somewhat short stature is due to their less than optimal diet and living conditions. This rather short stature combined with a relatively small number of adult males and weapons generally associated with free Iron-Age males may imply that mostly slave women, their children and an occasional male slave were buried at this site. It is, however, impossible to rule out the possibility that the Levänluhta bones derive from human sacrifices or victims of an epidemic.

Due to phenotypic plasticity of stature, there is no valid reason to exclude the Levänluhta people as among our ancestors due to their stature. Their mean stature could have increased to modern Finnish levels in just 100 years with improved diet and general living conditions. Meinander's (1950) assumption that the Levänluhta people were too short to be our ancestors is thus incorrect.

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