Patterns of Stature Variation in Medieval Sweden

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1. Introduction

The question of how human stature has changed in human history and how these changes have been affected by, in particular, environmental factors such as nutritional status, has long been of great interest to anthropologists and economic historians. Studies of secular changes in the stature of conscripted soldiers in Europe, for which there are consistent written records since the 18th century, have provided economic historians with significant data on which to base theories of economic change and development.[1] Studies of stature change based on data from osteo-archaeological material have been fewer (but see below). Unfortunately, in most cases the data for any one time period are limited and the question as to how representative the available samples are is moot. However, for the Middle Ages (in Sweden generally defined as the time between AD 1060 and 1520, the Early Middle Ages of continental Europe being considered late Iron Age in the Nordic countries) there are a number of samples available, and this allows for at least some general trends to be established and some historical hypotheses tested.

The demographic wave of the Middle Ages is characterized by a population increase from around 1000 AD to the early 14th century.[2] The Black Death turned increase to decrease, and for more than a hundred years the population was reduced in size. Among the reasons why the population did not bounce back faster were recurrent plagues, but changed social and demographic structures also played a role.

What interests us here is the discussion regarding how this major demographic wave influenced the living standards of ordinary people. Some hypotheses have earlier been presented.[3] The period of expansion could have ended in a Malthusian situation, with a decreasing production per capita as poorer land was brought into cultivation. This would have caused decreasing living standards, eventually preparing the ground for the plagues.[4] This theory has later been rejected, and the sustainability of Medieval agriculture has been emphasized.[5]

Discussions of the Late Middle Ages have concentrated on the effects of a decreasing population. This ought to have resulted in more available land for every person left and a change to more extensive agricultural methods, for instance a change from grain production to livestock production. Logically, this would lead to increased per capita food production. However, other causes, such as taxation pressure or growing investments outside agriculture, may also have played a role. English historians generally argue for a rising standard of living, even measured by food consumption, for ordinary people during the Late Middle Ages.[6] German historians have a more pessimistic view, and suppose many of the pea-

Code	Name	Age (approximate)	Sex	N (total)	Mean, femur M1 (N)	Mean, all (N)	Reference
A	Kv. Gambrinus, Jönköping	1370-17th century	Male	6	167.88 (4)	170.39 (5)	Sten 1982b
B	Kv. Nunnan, Sigtuna	1000-1200	Female	6		164.57 (6)	Anttila 1987
			Male	21		174.48 (14)	
C	Nödinge church	High Middle Ages	Female	3	163.71 (2)	163.21 (3)	Vretemark 1982a
D	Österlövsta, Old cemetery	1150-1451	Female	2		159.83 (2)	Vretemark 1982b
E	Björnlunda church	11th century	Female	1		169.31 (1)	Sten 1987
F	Kv. Torget, Uppsala	1480	Male	1	180.01 (1)	179.36 (1)	Sten 1982a
G	St. Klemens church, Visby	1250	Female	1	155.05 (1)	144.99 (1)	Sjøvold et al. 1974
H	Kv. Kyrkberget, Strängnäs	1005	Male	1		163.58 (1)	Wigh 1996
I	St. Klemens church ruin, Visby	900-1200	Female	3	153.89 (3)	153.89 (3)	Backman 1911
			Male	7	169.63 (7)	169.63 (7)	
K	Lund cathedral	11th - 13th century	Female	1	166.47 (1)	166.54 (1)	Hjortsjö & Krakau 1944
			Male	6	174.84 (6)	174.98 (6)	
L	Björned, Torsåker	12th century	Female	2	164.17 (2)	164.57 (2)	Hårding 1996
			Male	13	172.47 (13)	174.32 (13)	
M	Kv. Kroken, Uppsala	1300-1500	Female	22	157.45 (16)	157.87 (19)	Sigvallius 1989
			Male	22	171.33 (19)	171.83 (22)	
O	Westerhus, Frösö parish	1050-1350	Female	74	161.66 (72)	161.49 (74)	Gejvall 1960
			Male	63	173.03 (62)	173.87 (63)	
P	Löddeköpinge	1050-1150	Female	136	156.35 (129)	157.05 (136)	Persson & Persson 1981
			Male	191	168.18 (180)	169.31 (191)	
Q	Helgeandsholmen, Stockholm	1300-1530	Female	134	157.71 (112)	157.38 (129)	Sjögren 1979-1982
			Male	216	169.88 (176)	170.41 (202)	
R	Leksand church, Leksand	1030-1400	Female	70	162.45 (35)	160.35 (54)	Sjøvold 1982
			Male	31	172.68 (11)	175.94 (22)	
S	St. Petri chapel, Leksand	17th century	Female	13	163.62 (11)	162.32 (13)	Holm 1996
			Male	15	169,55 (15)	168,08 (15)	
T	Skara cathedral, Skara	1050-1075	Male	1	178,44 (1)	176,94 (1)	Gejvall, Hjortsjö & Lindh 1951
U	Tullgatan, Enköping	1300	Male	2	168,64 (2)	170,04 (2)	Anund 1993
V	St. Andreas church, Lund	1050-1100	Female	55	159.1*		*Data from Arcini 1999
			Male	80	170.9*		
W	Fjälkinge	900-1050	Female	20	159.9*		*Data from Arcini 1999
			Male	22	170.3*		
X	Trinitatis church, Lund T1	990-1020/30	Female	30	159.6*		*Data from Arcini 1999
			Male	48	173.6*		
	Trinitatis church, Lund T2-3	1020/30-1100	Female	76	160.9*		*Data from Arcini 1999
			Male	91	171.5*		
	Trinitatis church, Lund K3	1050-1100	Female	22	161.5*		*Data from Arcini 1999
			Male	50	172.5*		
	Trinitatis church, Lund D3	1050-1100	Female	12	162.8*		*Data from Arcini 1999
			Male	11	174.6*		
	Trinitatis church, Lund T4	1100-1300	Female	83	160.4*		*Data from Arcini 1999
			Male	110	171.2*		
	Trinitatis church, Lund T5	1300-1536	Female	124	160.4*		*Data from Arcini 1999
			Male	161	172.2*		
	Trinitatis church, Lund T	1300-1536	Female	16	161.2*		*Data from Arcini 1999
			Male	28	173.8*		

Fig. 1. List of material used in the analyses herein. This list does not represent all available material, only those samples that have dates that could be reasonably identified as either High or Late Middle Ages. The Codes correspond to those in fig. 2. Numbers in parentheses indicate the number of specimens the mean is based on.

sants in the 15th century to have been as bad or worse off than before.[7]

For Sweden, written sources about the consumption and production of food in the Middle Ages are extremely few, and the osteo-archaeological material is our main source. This, however, means that other issues must be taken into account in the analysis, since the stature and general health status of men and women are determined by several factors, including genetic ones.

From historical sources we know more about the post-Medieval situation, but for this period we have less osteo-archaeological material. The 16th century saw renewed agrarian growth, which came to a halt in the early 17th century. Population growth continued, however, and at least by the 17th century food production did not keep pace with population growth. This could partly be solved by increasing the import of grain from the Baltic States, but most probably the standard of living fell in 17th century Sweden.[8]

2. Previous work

A substantial body of work has been published on the stature of various Medieval populations of Sweden and the rest of Scandinavia. However, the vast majority of this work has been in the form of descriptive reports without an analytical component and lacking comparisons between different populations. Even in the very extensive work by N.-G. Gejvall (1960) on Westerhus, Frösö Parish, Jämtland, the only comparison was with the Neolithic material from Västerbjers, Gotland.

It was not until the 1980s that broader comparisons between different skeletal populations (which are not necessarily populations in a biological sense)

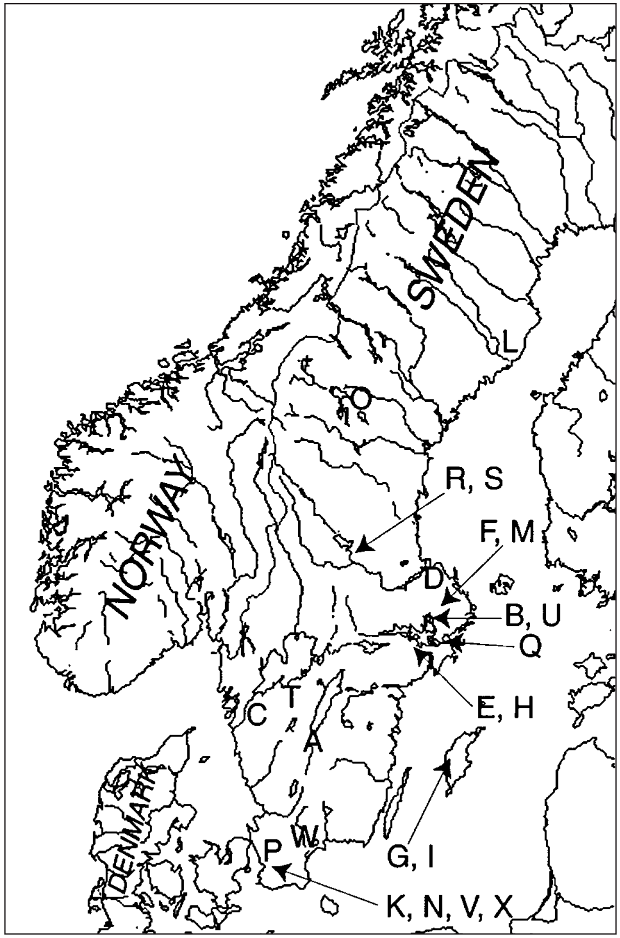

Fig. 2. Map of part of Fennoscandia showing the approximate location of the samples discussed in the text. The letters used refer to the Code given in fig. 1.

began to be made. J. Boldsen has looked at temporal and regional variation in stature between skeletal populations from Denmark (Jutland) and Scania, Sweden (part of Denmark in Medieval times).[9] Most significant from the perspective of the present work is the discussion in Boldsen 1983 and Boldsen 1990, wherein differences in stature between urban and rural populations are suggested to be related to differences in heterozygosity between the respective populations. In this discussion, rural populations are suggested to be more inbred (due to limited population mobility) than urban populations and the short stature of the rural populations is hypothesized to be due to inbreeding depression or, alternatively, the greater stature of the urban populations to be due to heterosis.

L. Werdelin studied some Swedish skeletal populations, emphasizing within-population statistics, but also making comparisons between populations, including a discussion of patterns of sexual dimorphism.[10] B. J. Sellevold discussed sexual dimorphism in stature of Swedish, Danish, and Norwegian skeletal populations from the Neolithic to Medieval times.[11] No general conclusions were drawn in this study, however.

Most recently, C. Arcini, in a study of the medical history of some skeletal populations from Lund, Scania, presented data on secular trends in stature.[12] She concluded that, to the extent that her material was representative, there had been no significant changes in stature during the Middle Ages in Lund.

3. Material and methods

This study employs measurement and stature data from a large selection of Swedish skeletal samples from late pre- to early post-Medieval times. The time span covered is approximately AD 900-1700. Herein, the High Middle Ages are taken as the time between ca. AD 1000 to AD 1350, and the Late Middle Ages as the time from AD 1350 to AD 1520. There is inevitably some overlap in the middle. The samples and some basic data are listed in fig. 1. The geographic coverage is indicated in fig. 2. It should be noted that the selection of samples has been dictated by Sweden's current political boundaries; the samples need not, and in many cases did not, belong politically to Sweden at the time they were formed.

It can be seen from fig. 1 that the samples are highly variable in size and composition. One of the most important concerns in our work has been the selection of variables to work with. There are essentially two main choices: either study the distribution of individual measurement variables, or study stature estimates based on regression analyses. The first of these choices has obvious statistical advantages in so far as the distributional statistics of stature estimates may be considered to some extent suspect. On the other hand, we have in the present case been limited to working with material measured or analyzed by others, since remeasuring all the material would be prohibitive in terms of time and cost. This has the unfortunate result that if we were to use only measurement data, the number of samples, as well as the number of individuals within each sample, would be considerably reduced. In particular, using the most commonly available variable, femur M1 length,[13] would lead to the loss of the important Löddeköpinge material, as only femur M2 has been published from that sample. We feel that adding a constant value to this measurement to obtain an approximate M1 as done by Boldsen[14] is no better statistically than using stature estimates. In addition, there are several samples for which we have stature estimates but no raw data and these would also be lost. Hence, we have elected to use stature estimates in the analyses despite their disadvantages.

Comparisons between populations can be viewed in several ways. The most natural is to compare means by pooling all individuals from each set of populations, and the statistical tests presented below are carried out on this basis. However, viewed in another way, pooling all individuals in this way might lead to a very large sample having an inordinate influence on the pooled mean, and for this reason we have also presented means based on the pooled means of all populations in a sample, thus weighting each sample equally, rather than each individual. In cases where we have not had access to data on individuals, sample means have been weighted by multiplying the mean of a population by the number of individuals in that population. The sum of these population products has then been divided by the number of individuals in all populations making up the sample, thus creating a weighted mean. This is unsatisfactory in many ways, but has been rendered necessary by the nature of the material available.

A great many methods for stature estimation have been presented. Nearly all of these have been based on regression analyses of bone lengths against living stature of people of known height. The most extensive such work was carried out by M. Trotter and G. C. Gleser.[15] Using these methods to estimate the stature of past peoples of unknown ethnicity is difficult at best, since these estimates are heavily dependent on the characteristics of the ethnic group on which they are based. Another problem is that the Trotter and Gleser equations have been shown to overestimate stature by up to 5-6 cm.[16] Whether this error is linear is unclear, adding to the problem. A third problem is that the equations for men and women are based on very unequal material, as Trotter and Gleser mainly worked with conscripted soldiers killed in wartime. Nonetheless, the equations of Trotter and Gleser are commonly used to estimate the stature of skeletal populations of various times in the past. Examples from Scandinavia include Werdelin (1985) and Sellevold (1993).

J. Boldsen has,[17] after demonstrating the problems with the equations of Trotter and Gleser, taken different approaches, either estimating stature from measurements taken in the grave or using long bone (femoral) lengths for analyses without converting these to stature estimates. When feasible, the latter approach is clearly superior in many ways, but it does reduce sample sizes significantly. Since the material used in this paper has already been excavated, we were precluded from using the former approach. However, since we are comparing only skeletal populations from a relatively small geographic area and not using living populations at all, the problems these methods were designed to correct for should be relatively small herein.

In order to resolve some of the problems of the Trotter and Gleser equations, T. Sjøvold developed new regression estimates for stature.[18] He calculated the reduced major axis regression equation on the means of a large number of skeletal samples of varying ethnicity and sex, and thereby obtained equations for different bone measurements that he called "the line of organic correlation". He presented two groups of results, one for all Caucasians independent of sex and one for all ethnic groups independent of sex. These equations thus have the advantage of being the same for both sexes and (in the case of the second set) the same for all ethnic groups. Since the material used spans over a wide stature range, the results are also less prone to problems of extrapolation.

In this paper we have considered several of these methods. The results presented are based on Sjøvold's equations for Caucasians.[19] They will be presented in two forms: as stature estimates based on femoral lengths only, and as stature estimates based on the average of all possible stature estimates (using humerus, radius, and femur) for each skeleton. The former is more stringent, while the latter gives larger sample sizes (and allows us to include samples for which no femora are known). The approach taken by Sjøvold should minimize the problems associated with mixing estimates in this way. This approach is analogous to that used by some in body mass estimation in paleontology, where the average of all available estimates has been used in specific cases.[20]

In cases where this was possible, significance was assessed using several methods. Although the Student t-test for the difference of means is relatively robust against violations of the assumption of normality, we report results for both this and the non-parametric Mann-Whitney U-test. Variances were compared by visual inspection and when it was deemed likely that the samples compared had significantly different variances the separate variance t-test was used. In other cases the variances were pooled.

4. Results

The basic result comparing stature in High and Late Medieval times in Sweden is shown in fig. 3. As can be seen, the differences are slight for both males and females. No statistical comparison can be made, since the data do not come from uniform sources, but it is likely that the Late Medieval female sample is significantly shorter than the one from High Medieval times. The difference for males is less likely to be significant. Either way, the differences are small. The conclusion is that mean stature for males was 172-173 cm and for females 159-160 cm throughout the Middle Ages in Sweden.

It may, on the other hand, be questioned whether such a comparison is of any significance, since it mixes data from different regions of Sweden, gene flow between which was probably limited in Medieval times, as well as data from samples with varying socioeconomic status. In particular, the comparison mixes urban and rural sites. Since Boldsen has shown that Danish urban and rural samples differ in stature[21] it may be surmised that the same would be true in Sweden and hence the comparison in fig. 3 is strongly influenced by the specific mixture of such sites in the pooled samples from different time periods. More meaningful comparisons can be made if the material is separated into more geographically and socioeconomically homogeneous samples. There are few such possible comparisons to be made and those that are possible do not necessarily reflect the most interesting *a priori* hypotheses that could be asked. Nevertheless, they are reported below and assessed for significance.

The first comparison concerns urban samples from east central Sweden, and the comparison is between samples from the High and Late Middle Ages. Unfortunately, the sample from the High Middle Ages comes from only one rather small site (kv. Nunnan, Sigtuna), while the Late Middle Age sample is considerably larger. Hence, the comparisons are of somewhat limited value. In the case of males, the comparison produced no significant differences (mean HMA = 174.48, mean LMA = 170.55; separate variance $t = 1.439$, $df = 13.7$, $p = 0.173$; Mann-Whitney $U = 1098$, $p = 0.060$). In the case of females, however, the comparison is significant (mean HMA =

Time period	Sex	Mean stature, Femur M (N) (from individuals)	Mean stature, Femur M1 (from samples)	Men stature all data (N) (from individuals)	Mean stature all data (from samples)
High Middle Ages	Female	158.32 (210)	160.19	158.85 (228)	160.54
Late Middle Ages	Female	157.67 (128)	157.58	157.44 (148)	157.62
High Middle Ages	Male	169.72 (272)	172.26	170.88 (299)	172.25
Late Middle Ages	Male	170.07 (196)	172.47	170.59 (225)	172.91

Fig. 3. Summary data on stature on the High and Late Middle Ages. Data from individuals were used as the basis for the discussion in the text. Numbers in parentheses indicate the number of specimens the mean is based on.

164.57, mean LMA = 157.44; pooled variance t = 3.042, df = 152, p = 0.003; Mann-Whitney U = 158, p = 0.008). Thus, there is significant change in female, but not male, stature from the High to the Late Middle Ages at these sites.

The second comparison concerns the two samples from Leksand (central Sweden), one Medieval and one post-Medieval. These samples are small, and hence more equal in size than in the previous set of comparisons. In this case, the comparison between males is significant (mean LMA = 175.94, mean postMA = 168.08; pooled variance t = 2.823, df = 35, p = 0.008; Mann-Whitney U = 83, p = 0.011), while the comparison between females is not (mean LMA = 160.35, mean postMA = 162.32; pooled variance t = 1.105, df = 65, p = 0.273; Mann-Whitney U = 402, p = 0.419). Hence, male, but not female, stature changes significantly in Leksand from the Medieval to post-Medieval times.

The third comparison concerns samples from Scania, southernmost Sweden. Here we are in a more difficult position, as we only have data on individuals for a part of the Scanian material. Much additional data is provided by C. Arcini,[22] but inclusion of this material clearly creates problems for statistical analysis. Without this material our samples are too limited to be useful. Fortunately, C. Arcini, like us, used the method of Sjøvold in calculating stature, and the results are therefore at least methodologically comparable.[23]

Another question concerns what can be compared in Scania. Two types of comparisons suggest themselves: comparisons between High and Late Middle Ages and comparisons between town and countryside. In the previous comparisons, only the former type was possible, but Scania provides material from both town (Lund) and countryside. As Lund was the seat of the mighty archbishop of Denmark, this difference is accentuated, and the administrative center more concentrated to this town than it would be in the case of other, similarly sized towns.

Comparisons between the High and Late Middle Ages essentially become identical to those already carried out by C. Arcini.[24] No statistical testing is possible since we do not have access to data on individuals, but the differences between the two time periods are small both for males and females, and are not likely to be significant. Thus, stature does not seem to have changed in Lund from the High to the Late Middle Ages.

The comparisons between political center and surrounding province show a quite different pattern. These comparisons were made on material from the High Middle Ages and show that both males and females from Lund are taller than those from the surrounding province (fig. 4). By comparison with the analyses of east central Sweden it is evident that these differences must be significant, and we can unequivocally state that the people of Lund were taller than those of the surrounding countryside.

A final set of comparisons is geographically based (fig. 4). Here we have compared pooled samples from northern Sweden, east central Sweden, and Scania (Lund and the remaining province taken separately) for both High and Late Middle Ages. Again, we are unable to make statistical comparisons due to a lack of data at the individual level for the samples from Lund. For the High Middle Ages, both male and female populations from northern and east central Sweden can be seen to be taller than the populations from Scania (although the sample from east central Sweden is very small). The difference is especially marked for males. The comparison for the Late Middle Ages is more limited, as it includes only east central Sweden (with a considerably larger sample this time) and Scania (Lund). The comparison is thus between two sets of urban populations. In this case it is the Scanian population that is the taller, reversing the situation of the High Middle Ages.

Some comment must finally be made about the pattern of sexual dimorphism. Werdelin suggested that differences in sexual dimorphism in stature between different Medieval populations might be a good indicator of nutritional status.[25] This belief was based on earlier hypotheses that the stature of women is more robust against nutritional stress than is that of men.[26] Thus, high dimorphism should reflect good nutritional status of a population, since the surplus nutrition is transformed into greater stature in men more readily than in women. Conversely, low sexual dimorphism in stature should reflect poor nutritional status.

L. Werdelin had only a few samples to work with in his analysis.[27] In this study there are many more and this allows us to address this issue once again. We may note, like Werdelin and Sellevold, that differences in sexual dimorphism between different populations are considerable (fig. 5).[28] We suggest the following test of the hypothesis of Werdelin:[29] if the hypothesis is correct, and patterns of sexual dimorphism are due to the factors suggested, especially female buffering against nutritional deficiency, then the among sample variance for females should be expected to be less than that for males. Inspection shows that this hypothesis is false. In fact, it is the among sample variance for females that is the greater (varM = 14.303, varF = 46.268, F-ratio = 3.235). Thus, the hypothesis presented by Werdelin to account for the pattern of sexual dimorphism seen in Medieval Swedish populations can be considered falsified.

5. Discussion

In the following discussion the results of the comparisons presented above will be scrutinized and some hypotheses to account for these results presented. Some comments on previous attempts to study stature variation in Medieval times will also be provided.

The overarching result is that there was no or only minor (females) stature change from the High to the Late Middle Ages. What change there was seems to

Time period	Sex	Region	Mean, femur M1 (from samples)	Mean, all (from samples)	Weighted mean, all (N)
High Middle Ages	Female	North central Sweden	162.91	163.03	161.57 (76)
		East central Sweden		164.57	164.57 (8)
		Scania, Lund	161.54	161.55	160.44 (288)
		Scania, province	158.12	158.47	157.41 (156)
	Male	North central Sweden	172.75	174.09	173.95 (76)
		East central Sweden		169.03	173.75 (15)
		Scania, Lund	172.30	172.81	171.82 (397)
		Scania, province	169.24	169.81	169.42 (213)
Late Middle Ages	Female	East central Sweden	157.58	157.62	157.44 (148)
		Scania, Lund	160.80	160.80	160.49 (140)
	Male	East central Sweden	172.47	172.91	170.58 (227)
		Scania, Lund	173.00	173.00	172.44 (189)

Fig. 4. Summary data on stature in three geographic regions. Numbers in parentheses indicate the number of specimens the mean is based on.

have been in the direction of shorter stature, which, if stature can be taken as an indicator of nutritional status, is in contradiction to suggestions that there was an improved standard of living in Sweden subsequent to the Black Death. Nor do the very small differences allow the opposite argument, that the standard of living declined in the Late Middle Ages. However, it is still possible that regional changes reflect changing standards of living, and to get some idea of whether this is the case we turn to the detailed comparisons.

We will begin with the Scanian comparisons, which although not amenable to statistical analysis, nevertheless are the most clear cut. There was no apparent stature change from the High to the Late Middle Ages, which is in accordance with the results from the overall analysis. The comparison between Lund and the rest of Scania showed that the former sample was taller. There are several possible explanations for this pattern, which needs to be discussed in the context of the analyses of Boldsen of Danish skeletal material.[30]

Since in his work Boldsen used the contemporary political boundaries to delineate Medieval Denmark, rather than the modern ones, his samples overlap with ours in including Scanian material. He pools material from both High and Late Middle Ages. In our opinion, these results suggest that both rural and urban males from Jutland were taller than males from Scania, and than urban males were taller than rural males in both Jutland and Scania. For females the situation is slightly different. Rural Jutland females were taller than rural Scanian females, but there is no difference between the two urban samples. Urban Scanian females were taller than rural Scanian females, but in Jutland the situation was the opposite, with rural females taller. Thus, for the

Name	Age	Dimorphism (absolute, cm)	Dimorphism (relative, %)
Kv. Nunnan, Sigtuna	1000-1200	9.91	6.02
St. Klemens church ruin, Visby	900-1200	15.74	10.23
Lund cathedral	11th-13th century	8.44	5.07
Björned, Torsåker	12th century	9.74	5.92
Westerhus, Frösö parish	1050-1350	12.38	7.67
Löddeköpinge	1050-1150	12.27	7.81
Leksand church, Leksand	1030-1400	15.59	9.72
Kv. Kroken, Uppsala	1300-1500	13.96	8.84
St. Petri chapel, Leksand	17th century	5.76	3.55

Fig. 5. Summary data on sexual dimorphism.

Scanian samples Boldsen's results are identical with ours, showing that the difference in methodological approach has not affected the results significantly.

Despite the mixed results for males and females, Boldsen goes on to suggest a general model for urban stature increase based on a decrease in inbreeding. It should be evident from what was stated above that this model can only hold for males, since females show an entirely different pattern, but this difference is not touched upon by Boldsen. In general it is rather difficult to envisage a genetic model that would lead to increased male stature with increasing heterozygosity and not increased female stature. Such a model would necessarily be dependent either on *y*-linked genes, or on an *x*-linked dosage effect, but since the heritable component of stature is clearly polygenic, it is not clear how the model would work. Testing Boldsen's hypothesis would also require investigating whether the Medieval rural populations were, in fact, as inbred as he suggests. This may become possible with modern methods in molecular genetics.

Though we cannot exclude Boldsen's hypothesis as an explanation for our observed results, we should like to present an alternative with specific relevance to Scania (but not Jutland). Lund was an important administrative center, the seat of the powerful Danish archbishop. Such an important administrative center would be likely to attract households from well-to-do classes. These may have had better nutritional status than other sectors of the general population. In the particular case of Lund, moreover, these individuals were likely to have come from more westerly parts of Denmark, and since we know that at least the populations of Jutland were taller than those of Scania, this will also lead towards selectively greater stature in Lund than in the surrounding areas into which no such immigration was likely to occur. Thus, we suggest that the greater stature of people in Lund compared to the surrounding area was due to immigration of western Danes with relatively high social status.

The comparison between populations from east central Sweden allows us to generalize this hypothesis. The High Middle Ages sample used here comes from the town of Sigtuna, which was another important religious administrative center in the Middle Ages. This sample is, as we have seen, significantly taller than the urban materials from Late Middle Ages Uppsala and Stockholm. We thus propose a more general hypothesis: that populations from administrative centers (particularly physically smaller ones, lacking a significant urban sprawl) will be found to be taller than those from other parts of the same geographic region due to a relatively greater proportion of well-to-do people of high social status associated with the administration itself.

The final pairwise comparison was that for Leksand, where it was seen that male stature changed significantly from Medieval to post-Medieval (17th century) times. This is in accordance with historical sources, which suggest that the standard of living fell during the 17th century. With the caveat that the methods of estimating stature are quite different, this change of stature in the early modern period can tentatively be compared with the earliest rolls of soldiers containing height measures. Such rolls became common in Europe in the 18th and 19th centuries. In Sweden measures of the height of military recruits goes back to about 1740, and the average height by the year of birth for these recruits can be taken back to about 1720. At that time the average height for young conscripts was 1.65 m. During the 18th century there was an increase in stature of soldiers to about 1.70 m around the year 1800 and in the early 19th century this growth continued, with some setbacks and plateaus in average height. In the middle of the century an average height of 1.72-1.73 m had been reached,[31] which is closely comparable to that of the Middle Ages as a whole, as derived from the osteo-archeological material (see above). Direct comparisons between height measures on recruits from the 18th century and on skeletons from the Middle Ages and 17th century has its difficulties, but if we take the data at face value it would appear that the stature decrease that is seen from the Middle Ages to the 17th century continued into the early 18th century and was not reversed until the middle and later parts of that century.

The differences between the different geographic regions identified above can be explained through the differences within each region and require no separate consideration. It is readily apparent that since the different regions have different patterns of change they probably also were partly isolated, leading to separate genetic histories.

In summary, we note that the results are rather disappointing regarding generality, mainly due to the biased material available. They do not corroborate nor definitively falsify any of the general historical hypotheses regarding the effects of, e. g., the Black Death on the nutritional status of Medieval Swedes. This may be due either to an insufficiency of the material or, alternatively, that the influence of nutritional status on stature is more limited than generally believed. We are inclined to believe that the second alternative may be important. This seems also to be the opinion of Boldsen,[32] since he constructs a genetic hypothesis to explain stature differences rather than invoking nutritional status. We are also inclined to formulate our explanations for perceived differences between localized sets of populations in this direction, though we believe that non-random mixing of populations with different genetic backgrounds (and hence different stature) may be more important than inbreeding *per se*. Thus, the case for linking stature and nutritional status must be reconsidered, all the more so because no plausible explanation couched in these terms can explain either the stature differences between populations and times or the observed patterns of sexual dimorphism in stature.

Notes

1. E. g. Sandberg & Steckel 1987, cf articles in *Journal of Economic History, European Review of Economic History, Economic History Review* during 1998-1999.
2. E. g. Bardet & Dupâquier 1997.
3. E. g. Iregren 1988.
4. Postan 1975.
5. Campbell 1991.
6. Britnell 1993; Dyer 1989.
7. Abel 1967; Rösener 1985.
8. Myrdal 1999.
9. Boldsen 1983; Boldsen 1990; Boldsen 1993.
10. Werdelin 1985.
11. Sellevold 1993.
12. Arcini 1999.
13. Cf. Martin & Saller 1957.
14. Boldsen 1990.
15. Trotter & Gleser 1952; Trotter & Gleser 1958.
16. Kieffer-Olsen, Boldsen & Pentz 1986.
17. Boldsen 1990; Boldsen & Kronborg 1984.
18. Sjøvold 1990.
19. Sjøvold 1990.
20. Fortelius & Kappelman 1993. For some problems with such an approach, see Trotter & Gleser 1952 and Sjøvold 1974.
21. Boldsen 1990.
22. Arcini 1999.
23. Arcini 1999; Sjøvold 1990.
24. Arcini 1999.
25. Werdelin 1985.
26. Tobias 1970.
27. Werdelin 1985.
28. Werdelin 1985; Sellevold 1993.
29. Werdelin 1985.
30. Boldsen 1983; Boldsen 1990; Boldsen 1993.
31. Sandberg & Steckel 1987.
32. Boldsen 1990.

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Litteratur

Abel, W.: *Geschichte der deutschen Landwirtschaft vom frühen Mittelalter bis zum 19. Jahrhundert*. Stuttgart 1967.

Anund, J.: Osteologisk analys. *Arkeologisk undersökning Tullgatan, RAÄ 23, Enköping, Uppland*. Riksantikvarieämbetet. Byrån för arkeologiska undersökningar. Uppsala 1993.

Anttila, K.: *Osteologisk analys av skeletten från Kv. Nunnan, Sigtuna kommun, Uppland*. Unpublished osteological report. The archives of the Museum of National Antiquities, Stockholm. 1987.

Arcini, C.: *Health and disease in early Lund. Osteo-pathologic studies of 3,305 individuals buried in the first cemetery area of Lund 990-1536*. Archaeologica Lundensia VIII. Lund 1999.

Backman, G.: Bidrag till kännedom om de medeltida svenskarnas antropologi. I. Kranier och skelett från S:t Clemens kyrkoruin i Visby. *Kungl. Svenska Vetenskapsakademiens handlingar*. Bd 47, no. 7. Uppsala & Stockholm 1911.

Bardet, J.-P. & J. Dupâquier (eds): *Histoire des populations de l'Europé 1. Des origins aux prémices de la révolution démographique*. Paris 1997.

Boldsen, J. L.: *Studier af humanbiologisk variation i fortid og nutid: metoder og resultater*. Licentiatafhandling. Afdeling for Teoretisk Statistik, Matematisk Institut, Aarhus Universitet 1983.

–:Height variation in the light of social and regional differences in Medieval Denmark. *From the Baltic to the Black Sea: Studies in Medieval Archaeology*. Ed. L. Alcock & D. Austin. London 1990, pp. 181-188.

–: Height variation in Denmark A. D. 1100-1988. *Populations of the Nordic countries. Human population biology from the present to the Mesolithic.* Ed. E. Iregren & R. Liljekvist. University of Lund, Institute of Archaeology, Report Series No. 46. 1993, pp. 52-60.

Boldsen, J. L. & D. Kronborg: The distribution of stature among Danish conscripts in 1852-56. *Annals of Human Biology* 11, 1984, pp. 555-565.

Britnell, R. H.: *The Commercialisation of English Society 1000-1500.* Cambridge 1993.

Campbell, B. (ed.): *Before the Black Death. Studies in the "crisis" of the early fourteenth century.* Manchester 1991.

Dyer, C.: *Standards of Living in the later Middle Ages: Social Change in England c. 1200-1520.* Cambridge 1989.

Fortelius, M. & J. Kappelman: The largest land mammal ever imagined. *Zoological Journal of the Linnean Society* 108, 1993, pp. 85-101.

Gejvall, N.-G.: *Westerhus. Medieval population and church in the light of skeletal remains.* Lund 1960.

Gejvall, N.-G., C.-H. Hjortsjö & J. Lindh: Antropologiska meddelanden i samband med den kulturhistoriska undersökningen i Skara Domkyrka 1947-49. *Kungliga Fysiologiska Sällskapets i Lund Förhandlingar* Bd. 21, no. 3, 1951, pp. 1-16.

Hjortsjö, C.-H. & T. Krakau: Antropologiska data beträffande befolkningen i Lund under 1000-1100- och 1200-talen. *Lunds universitets årsskrift* N. F. 2, Bd. 40, no. 4, 1944

Holm, S.: Bilaga 4. Osteologisk rapport. I: Gustin, I.: Gravar från tidig modern tid under St Petri kapell. *Riksantikvarieämbetet, Arkeologiska undersökningar. UV Stockholm, Rapport* 1996, no. 104, pp. 49-78.

Hårding, B.: *Begravningsplatsen i Björned. En arkeo-osteologisk analys av den medeltida begravningsplatsen i Björned, RAÄ 23, Torsåkers socken, Ångermanland.* Unpublished osteological report. The archives of the Museum of National Antiquities, Stockholm. 1996.

Iregren, E.: Människor i medeltid – historia och biologi i ett samhällsperspektiv. Ett planerat projekt vid avdelningen för medeltidsarkeologi vid Lunds universitet. *Gravskick och gravdata.* Ed. E. Iregren, K. Jennbert & L. Larsson. University of Lund, Institute of Archaeology, Report Series No. 32. Lund 1988, pp. 37-54.

Kieffer-Olsen, J., J. L. Boldsen & P. Pentz: En nyfunden kirke ved Bygholm. *Vejle Amts Årbog* 1986, pp. 24-51.

Martin, R. & K. Saller: *Lehrbuch der Anthropologie in systematischer Darstellung.* Stuttgart 1957.

Myrdal, J.: *Jordbruket under feodalismen 1000-1700.* Stockholm 1999.

Persson, O. & E. Persson: *The Löddeköpinge Investigation V. Report on the anthropometrics of the skeletons from the early medieval century in Löddeköpinge (Scania, S. Sweden).* University of Lund, Institute of Archaeology, Report Series No. 19. Lund 1981.

Postan, M. M.: *The Medieval Economy and Society.* Harmondsworth 1975.

Rösener, W.: *Bauern im Mittelalter.* München 1985.

Sandberg, L. G. & R. H. Steckel: Heights and economic history: the Swedish case. *Annals of Human Biology* 14, 1987, pp. 101-110.

Sellevold, B. J.: Sexual dimorphism in some medieval Scandinavian skeletal groups. *Populations of the Nordic countries. Human population biology from the present to the Mesolithic.* Ed. E. Iregren & R. Liljekvist. University of Lund, Institute of Archaeology, Report Series No. 46. Lund 1993, pp. 94-104.

Sigvallius, B.: Kvarteret Kroken. Rapportserie från Osteologiska enheten, Statens historiska museum. *Osteologisk rapport* 1989:1.

Sjøgren, J.: *Helgeandsholmen, Stockholm.* Unpublished measurements 1979-1982. ATA (Antikvariskt Topografiskt Arkiv, Riksantikvarieämbetet, Stockholm).

Sjøvold, T.: Some aspects of physical anthropology on Gotland during Middle Neolithic times. *Gotlands mellanneolitiska gravar.* Ed. G. O. Janzon. Stockholm 1974.

–: Skelettfynden. *Tusen år på Kyrkudden. Leksands kyrka, arkeologi och byggnadshistoria.* Ed. B. Dandanell. Dalarnas fornminnes- och hembygdsförenings skrifter 25. 1982, pp. 165-178.

–: Estimation of stature from long bones utilizing the line of organic correlation. *Human Evolution* 5, 1990, pp. 431-447.

Sjøvold, T., I. Swedborg & L. Diener: A pregnant woman from the Middle Ages with Exostosis Multiplex. *Ossa International Journal of Skeletal Research* No. 1, 1974, pp. 3-23.

Sten, S.: *Franciskanerklostret kv. Torget, Uppsala.* Unpublished osteological report. The archives of the Museum of National Antiquities, Stockholm. 1982a.

–: *Kv. Gambrinus, Jönköping stad.* Unpublished osteological report. The archives of the Museum of National Antiquities, Stockholm. 1982b.

–: *Osteologisk analys, Björnlunda kyrka, Södermanland.* Unpublished osteological report. The archives of the Museum of National Antiquities, Stockholm. 1987.

Tobias, P. V.: Puberty, growth, malnutrition and the weaker sex and two new measures of environmental betterment. *The Leech* 40, 1970, p. 101.

Trotter, M. & G. C. Gleser: Estimation of stature from long bones of American whites and negroes. *American Journal of Physical Anthro-*

pology 10, 1952, pp. 463-513.
–:A re-evaluation of estimation of stature based on measurements of stature taken during life and long bones after death. *American Journal of Physical Anthropology* 16, 1958, pp. 79-123.
Vretemark, M.: *Osteologisk analys av fyra skelett från Nödinge kyrka i Västergötland.* Unpublished osteological report. The archives of the Museum of National Antiquities, Stockholm. 1982a.
–: *Osteologisk analys av skelett från Gamla kyrkogården, Österlövsta sn i Uppland.* Unpublished osteological report. The archives of the Museum of National Antiquities, Stockholm. 1982b.
Werdelin, L.: The stature of some medieval Swedish populations. *Fornvännen* 80, 1985, pp. 133-140.
Wigh, B.: Osteologisk analys. *Arkeologiska provundersökningar och antikvarisk kontroll: Kv. Kyrkberget 11, 12, Strängnäs, Södermanland, RAÄ 314.* Ed. M. Lindh. UV-Rapport/UV 1996:21. Stockholm. 1996.