Secular changes in tooth size in Swedish men

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Tooth size in present-day material consisting of 123 randomly selected inductees aged 18—26 years in the west of Sweden was compared with that in skeletal material from men from the south-west of Sweden who had died during the year 1810 at 18—25 years of age.

Tooth-size in the present-day population was measured on casts and in the skeletal material directly on the teeth. The following variables were studied: mesio-distal and facio-lingual width of the crowns and in the skeletal material also the maximal length of the teeth and the height of the crowns. In the skeletal material occlusal attrition was also assessed according to a 4-grade scale.

The mesio-distal width and facio-lingual width of the teeth were greater in the present-day material than in the skeletal material and for most of the teeth the differences were significant. The occlusal attrition was distinct in the skeletal material and most pronounced in front teeth and first molars. The results show that secular changes have occurred in tooth size during the last 160 years.

Key-words: Tooth size; tooth abrasion

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In a previous investigation it was shown that during the last 160 years the secular increase in stature has been accompanied by an increase in the size of the cranium (*Ingervall, Lewin & Hedegård,* 1972). The material studied was representative of the young male (adult) population of the south-west of Sweden in the beginning of the last century and to-day. The secular cranial changes included changes in the cranial base, suggesting changes also in the genetic constitution of the population in west Sweden during the period covered by the investigation (1810 until to-day). It is, however, not known whether the changes in stature and cranium are accompanied by changes also in the size of the teeth. This question was the subject of the present investigation.

MATERIAL AND METHODS

The present-day material consisted of 123 men, randomly selected from 312 inductees, aged 18—26 years (mean age 18.7 years), from west Sweden.

Men living in Sweden 160 years ago were represented by remains from a mass grave of soldiers who had died from epidemic typhus in 1810. The skeletal material, which was representative of the healthy male population, aged 18—25 years, in the south-west of Sweden in the

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beginning of the last century (*Engström, Lewin & Öberg*, 1972) consisted of dentigerous upper and lower jaws as well as separate teeth withouth their pertinent jaws. The remains had apparently belonged to at least 116 individuals (*Engström et al.*, 1972). Both materials have been described in detail previously (*Ingervall et al.*, 1972).

The sizes of the teeth in the present-day material were measured on stone casts made from alginate impressions. In the skeletal material the sizes of the teeth were measured either with the teeth still in the jaws or, if they were no longer in the jaws, held in the hand. To measure the maximal length of the tooth, the latter was removed from the jaw when possible. The measurements were made with a specially ground caliper (sliding caliper) to the nearest tenth of a millimeter.

The following measurements were made: Mesio-distal width of crown (WMD). The distance between the anatomic points of contact of the proximal surfaces.

Facio-lingual width of crown (WFL). The distance between the most prominent point on the facial surface and the most prominent point on the lingual surface, measured at right angles to the mesio-distal diameter.

The mesio-distal and facio-lingual width of the crown was measured in both the present-day material and the skeletal material. In the skeletal material measurements were also made of the following: Maximal length of tooth (ML). The distance between the incisal edge or the tip of the mesio-facial cusp and the apex.

Height of crown (CH). The distance between the incisal edge or the tip of the mesio-facial cusp and the most apical point of the facial gingival margin, measured perpendicular to the mesio-distal diameter.

In the present-day material no measurements were made of teeth with plaque or calculus reproduced on the cast. The facio-lingual width of teeth, whose prominence line was below the level of the soft tissues on the cast could not be measured (this applies in particular to incisors and lower canines). Tooth fillings, if any, were disregarded when making the measerements. In the skeletal material no measurements were made of teeth showing signs of erosion. All the measurements were made by one examiner.

In addition to the above measurements the degree of occlusal attrition in the skeletal material was appraised according to Lysell (1958). The scale used was as follows:

0 = no attrition
1 = attrition of enamel only
2 = dentine visible on the greater part of the occlusal surface
3 = involvement of the dentine, so that the secondary dentine was exposed or the pulp cavity opened.

Error of Method

The precision of the method, was estimated from double measurements of randomly selected teeth from the skeletal material.

In the examination for systematic differences between double determinations the mean difference between the two determinations was tested with the t-test. The accidental error, s(i), was calculated according to the formula $s(i) = \sqrt{\frac{\Sigma d^2}{2n}}$

Double determinations were made of the mesio-distal width (WMD) of 29 upper and lower teeth (molars, premolars, canines and incisors), of the facio-lingual width (WFL) of 34 teeth and the height of the crown (CH) of 29 teeth. No syste-

matic differences were found between the double determinations. The accidental errors were:
0.10 mm for the mesio-distal width of the crown (WMD)
0.12 mm for the facio-lingual width of the crown (WFL), and
0.28 mm for the height of the crown (CH).

No difference at all was found between double determinations of the degree of attrition of 35 teeth.

Systematic differences, if any, of the mesio-distal (WMD) and the facio-lingual (WFL) width between measurements made on stone casts and directly on the teeth were studied by direct measurement of 10 dentigerous jaws and stone casts of the same jaws. No significant difference was found between the measurements made directly on the teeth and on the casts. This applies to individual groups of teeth (upper molars, lower molars, upper premolars, lower premolars and front teeth), and to the results obtained when all teeth were pooled. The average difference found on comparison of the mesio-distal width of 61 teeth measured directly and on casts was 0.02 mm. The corresponding value of the facio-lingual width of 85 teeth was — 0.03 mm. These values, which are far from being statistically significant suggest that direct measurement tends to give a slightly higher value for the mesio-distal width than measurement on cast, but a slightly lower value for the facio-lingual width.

RESULTS

The mesio-distal and the facio-lingual width of the teeth in the present-day material and in the skeletal material are given in Tables I and II. The average difference

Table I. *Mean mesio-distal width, in mm, of teeth in present-day and in skeletal material*

Tooth	Present-day material		Skeletal material		Difference	Tooth	Present-day material		Skeletal material		Difference
	n	$\bar{x}$	n	$\bar{x}$			n	$\bar{x}$	n	$\bar{x}$	
18	15	9.13	47	8.70	0.43	48	8	11.01	43	10.48	0.53
17	117	10.35	75	9.46	0.89***	47	102	10.66	68	10.64	0.02
16	122	10.99	70	10.34	0.65***	46	122	11.22	58	11.06	0.16
15	108	6.81	75	6.44	0.37***	45	111	7.22	63	7.00	0.22**
14	116	6.97	69	6.63	0.34***	44	114	7.21	65	6.80	0.41***
13	123	8.05	52	7.65	0.40***	43	121	7.00	42	6.91	0.09
12	122	6.81	26	6.51	0.30	42	116	6.06	34	5.93	0.13
11	118	8.80	15	8.63	0.17	41	110	5.44	20	5.21	0.23**
21	114	8.84	17	8.56	0.28	31	109	5.46	15	5.17	0.29*
22	120	6.83	20	6.71	0.12	32	112	6.07	34	5.98	0.09
23	123	8.04	50	7.57	0.47***	33	120	6.95	42	6.93	0.02
24	109	7.00	59	6.73	0.27***	34	111	7.21	52	6.79	0.42***
25	110	6.76	69	6.51	0.25***	35	104	7.23	58	6.91	0.32***
26	119	10.90	66	10.29	0.61***	36	119	11.21	57	10.71	0.50**
27	105	10.31	75	9.34	0.97***	37	103	10.74	63	10.55	0.19
28	11	9.00	42	8.71	0.29	38	10	10.64	39	10.31	0.33

* $= 0.01 < p < 0.05$
** $= 0.001 < p < 0.01$
*** $= p < 0.001$

Table II. *Mean facio-lingual width, in mm, of teeth in present-day and in skeletal material*

Tooth	Present-day material		Skeletal material		Difference	Tooth	Present-day material		Skeletal material		Difference
	n	$\bar{x}$	n	$\bar{x}$			n	$\bar{x}$	n	$\bar{x}$	
18	17	10.51	53	10.70	-0.19	48	12	10.48	46	9.50	0.98***
17	117	11.46	75	11.15	0.31**	47	114	10.53	68	9.96	0.57***
16	123	11.52	68	11.17	0.35**	46	116	10.70	61	10.32	0.38***
15	109	9.42	67	9.11	0.31***	45	111	8.51	58	8.17	0.34***
14	117	9.19	61	8.94	0.25***	44	112	7.89	64	7.55	0.34***
13	104	8.59	54	8.36	0.23*	43	50	7.93	53	7.59	0.34**
12	62	6.64	32	6.38	0.26**	42	27	6.63	37	6.20	0.43***
11	61	7.39	26	7.10	0.29**	41	24	6.40	29	5.75	0.65***
21	59	7.41	31	7.14	0.27**	31	26	6.34	27	5.62	0.72***
22	63	6.65	28	6.30	0.35**	32	28	6.52	42	6.20	0.32**
23	101	8.63	49	8.27	0.36***	33	46	7.77	48	7.75	0.02
24	109	9.30	57	8.92	0.38***	34	103	8.87	51	7.58	1.29***
25	111	9.53	61	9.13	0.40***	35	103	8.55	56	8.11	0.44***
26	120	11.53	67	11.33	0.20	36	113	10.77	58	10.46	0.31***
27	115	11.47	73	11.02	0.45**	37	106	10.60	63	9.99	0.61***
28	11	10.87	40	10.55	0.32	38	9	10.29	36	9.59	0.70*

*$=0.01<p<0.05$
**$=0.001<p<0.01$
***$=p<0.001$

between the two materials was tested with Mann-Whitney's U-test. The frequency of possibly false significances was calculated according to *Eklund & Seeger* (1965).

The mean mesio-distal width of the teeth was invariably numerically larger in the present-day material than in the skeletal material (Table I). For the upper jaw the difference was statistically significant for the first and second molars, for the premolars and for the canines. In the lower jaw the difference was significant for the premolars, the central incisors and the left first molar.

With but one exception, the upper right third molar, the facio-lingual width of the teeth was on the average numerically larger in the present-day material than in the skeletal material. The differences were statistically significant for all teeth except the upper third molars, the upper left first molar, and the lower left canine.

The parameters for the maximal length, crown height and attrition in the skeletal material are given in Table III. Since no systematic difference was found between the values for the teeth on the right and the left side, the values for both sides were pooled.

DISCUSSION

The accidental error in the present investigation of measurement of the mesio-distal width of the crown was of the same order as that reported by *Lundström* (1943), *Seipel* (1946, p. 27) and *Hasund* (1966, p. 14) and shows that the precision

Table III. *Means and standard deviations of maximal tooth length and crown height, in mm, and degree of attrition of teeth in the skeletal material. Values for right and left side pooled*

Tooth	Maximal tooth length		S.D.k.	Crown height		S.D.k.	Attrition		S.D.k
	n	$\bar{x}$		n	$\bar{x}$		n	$\bar{x}$	
18—28	16	16.91	3.06	81	6.50	0.71	38	1.07	0.33
17—27	10	18.62	4.25	144	6.94	0.65	140	1.18	0.38
16—26	5	15.20	5.66	132	6.46	0.74	166	1.60	0.51
15—25	18	20.72	1.26	127	6.87	0.96	146	1.42	0.46
14—24	10	20.28	1.21	110	7.50	0.99	120	1.45	0.48
13—23	40	26.11	4.15	84	9.95	1.33	109	1.65	0.50
12—22	25	22.50	1.86	46	9.17	1.48	56	1.50	0.41
11—21	20	22.69	1.54	61	10.00	1.38	60	1.80	0.53
48—38	2	12.60	2.40	76	6.25	0.78	31	1.15	0.23
47—37	3	18.40	0.79	133	6.18	0.99	106	1.28	0.39
46—36	5	20.06	0.50	129	5.80	0.92	116	1.69	0.49
45—35	28	22.09	1.52	108	6.94	1.08	105	1.33	0.42
44—34	25	22.15	1.42	108	7.63	1.02	106	1.36	0.44
43—33	21	24.92	2.78	73	10.28	1.35	76	1.54	0.44
42—32	10	22.40	2.09	79	8.38	1.52	70	1.71	0.50
41—31	8	20.49	2.77	53	7.52	1.48	61	1.86	0.49

of the measurement was good. The precision of measurement of the facio-lingual width was also good with an accidental error of the same order as that given by *Lysell* (1958).

Comparison of the values found for the mesio-distal and facio-lingual widths of the crown measured directly and on casts revealed no systematic differences between the two methods. The values obtained by direct measurement and by measurement of the casts were therefore comparable. Also *Lundström* (1943) and *Hunter & Priest* (1960) found only an insignificant difference between direct measurement of the mesio-distal widths of teeth in the jaw and on casts. On measurement of the mesio-distal width of the second premolars and molars, however, the values obtained by *Hunter & Priest* on intra-oral measurement were clearly larger than those obtained on measurement of cast. The authors claimed that intra-oral measurement is much more difficult than extra-oral. Their investigation is, however, not strictly comparable to the present study, in which all measurements were made extra-orally.

To assess the representativeness of the present-day material regarding tooth size, the mean values found for the mesio-distal width were compared with the results obtained in other investigations of Swedish material of to-day. For most of the teeth the mesio-distal widths found in the present-day material examined in this investigation were somewhat larger than those reported by *Lundström* (1944), but usually smaller than those given by *Seipel* (1946, p. 50). The differences, which might perhaps be due to different measuring instruments and measuring methods and to the use of different impression and model materials from Lundström's and Seipel's values are, however, small and not systematic. There is therefore no

reason to suspect that the present-day material in this investigation was not representative of the population of today as far as tooth size in concerned.

The average mesio-distal width of the teeth in the present-day material was invariably numerically larger than that in the skeletal material. For more than half of the teeth the difference was statistically significant. The results suggest a secular increase in tooth size in the present-day material compared with that in the skeletal material. The difference in mesio-distal width may, however, also be due to decreased tooth-width in the skeletal material because of proximal attrition. It is probable that a fair degree of proximal attrition had occurred in the teeth in the skeletal material since the occlusal attrition was considerable, and a positive correlation has been found between occlusal and proximal attrition (*Hasund*, 1965, 1966, p. 56). The mesio-distal width would therefore not permit any conclusions about any difference in tooth size between the present-day material and the older material.

However, also the facio-lingual width of the teeth was always larger in the present-day material than in the skeletal material, and the difference was statistically significant for most of the teeth. The facio-lingual width of teeth is not affected by attrition and fillings. This parameter therefore showed the existence of a true difference in tooth-size between the materials. The teeth in the present-day material were facio-lingually wider than those in the skeletal material. Such a difference is also probable for the mesio-distal width since a fairly strong positive correlation has been found between the mesio-distal and facio-lingual widths of teeth (*Selmer-Olsen*, 1949). The results are in line with *Hasund's* (1966, p. 63) observation that the mesio-distal width of the teeth in a Norwegian material dating back to the Middle Ages was smaller than in a Swedish present-day material, a difference which, according to the author, was probably not due solely to the proximal attrition in the material from the Middle Ages. Also *Lunt* (1969) found the teeth of mediaeval Danes to be smaller than those of modern white races. This was particularly the case on comparison with the teeth of modern Swedes.

In the skeletal material examined the occlusal attrition was less than that reported by *Lysell* (1958) for material from the Middle Ages. But the attrition followed the same pattern as in *Lysell's* (1958) and *Hasund's* (1965, 1966, p. 45) investigation of material from the Middle Ages and in *Beyron's* (1964) material of Australian aborigines. The attrition in both jaws was thus most pronounced in the front teeth, especially the central incisors, followed by the first molars. As in *Lysell's* investigation, the lower incisors and molars were abraded more than the corresponding upper teeth, while the opposite was true for the premolars.

The occlusal attrition does, of course, influence the values found for crown height and maximal tooth length, which are therefore strictly comparable only with teeth with the same degree of attrition.

In a previous investigation of cranial morphology on the same material as that used in this investigation (*Ingervall et al.*, 1972), the results suggested that secular changes in cranial base morphology were due to changes in the genetic constitution of the population. Since the size of the teeth is largely genetically determined (*Lundström*, 1948), also the findings in the present investigation suggest that the genetic constitution of the population has changed. Environmental factors, such

as changes in nutrition or in trace elements may, however, also influence human tooth size (*Møller*, 1967; *Bowden & Goose*, 1969). It is well known that during the last century environmental changes (mainly more efficient nutrition) have caused a progressive secular increase of adult stature in Swedes as well as in many other populations (*Acheson & Fowler*, 1964; *Udjus*, 1964; *Lewin*, 1973). The increase in tooth size is therefore probably a combined effect of a change in genetic and environmental factors.

It cannot be excluded that the increase in tooth-size in the present-day population may be a contributory cause of the high frequency of crowded teeth in the present generation. For the size of the dental arch has not increased at the samesrate as tooth-size. The width of the dental arch was found to be same or even smaller in the present-day population than in the skeletal material (*Ingervall et al.*, 1972). But the length of the dental arch was greater in the present-day material. This difference may, however, be due to insignificant proximal attrition in the present-day material. However, it is not known whether the lack of proximal attrition in the present-day material is completely compensated by increase in length of the dental arch.

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